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A JOURNEY IN BHUTAN: *A paper read at the Evening Meeting of the Society on 27 May 1935, by*

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BHUTAN is an independent state in the Eastern Himalayas. On the north and east it is bordered by Tibet; on the west by the Tibetan district of Chumbi, the scenery of which has been made familiar by successive expeditions to Mount Everest; and on the south by the British Indian Provinces of Assam and Bengal. Its extreme length from east to west is 190 miles, and its breadth, which varies considerably, extends to 90 miles at the widest point. The area is about 18,000 square miles, and the population has been estimated at about 300,000.

Communication between the hills of Bhutan and the plains of Bengal and Assam takes place through a series of mountain passes, known locally as Dooars, a word derived from the Hindustani *dwār*, meaning gate or entrance. This name is nowadays used also to denote the level tracts upon which these passes open. The Dooars, which contain much rich and fertile soil capable of high cultivation, are divided into two by the Sun Kosh river, which also forms the boundary between Assam and Bengal. The western or Bengal Dooars are for the most part now covered with tea gardens; but the eastern or Assam Dooars are still to a great extent covered in virgin forest and are not at all unlike the Nepal Terai. The present southern boundary of Bhutan runs along the foothills, and thus the country contains practically no flat land beyond a narrow strip only a few miles broad which has been retained in places. Prior to the war in 1865 the whole of the Dooars belonged to Bhutan. Geographically the country does not differ greatly from Nepal and Sikkim, and forms an extension eastwards of the latter countries. It possesses similar deep valleys and high mountain ridges, and suffers equally from a lack of communications.

The original inhabitants of Bhutan are believed to have been subjugated about two centuries ago by a band of military colonists from Tibet. In 1774 the East India Company concluded a treaty with the ruler of Bhutan; but repeated outrages on British subjects committed by the dwellers in the hills led from time to time to punitive measures, usually ending in the temporary

or permanent annexation of various parts of the Dooars. In November 1864 the eleven western or Bengal Dooars were thus annexed, and in the following year a treaty was concluded under the terms of which Bhutan was granted an annual subsidy on condition of good behaviour. Many years later, in 1910, this treaty was amended and by its terms the British Government undertook not to interfere in the internal administration of the country. On its part the Bhutanese Government agreed to be guided by the advice of the British Government in regard to its external relations.

The form of government in Bhutan, which existed from the middle of the sixteenth century until 1907, consisted of a dual control by the clergy and the laity as represented by Dharma and Deb Rajas. In 1907 however the Deb Raja, who was also Dharma Raja, resigned his position, and the Tongsa Penlop, or Governor, Sir Ugyen Wangchuk, was thereupon elected as the first hereditary Maharaja of Bhutan. He died in 1926 and was succeeded by the present ruler, Sir Jig-me Wangchuk, K.C.I.E.

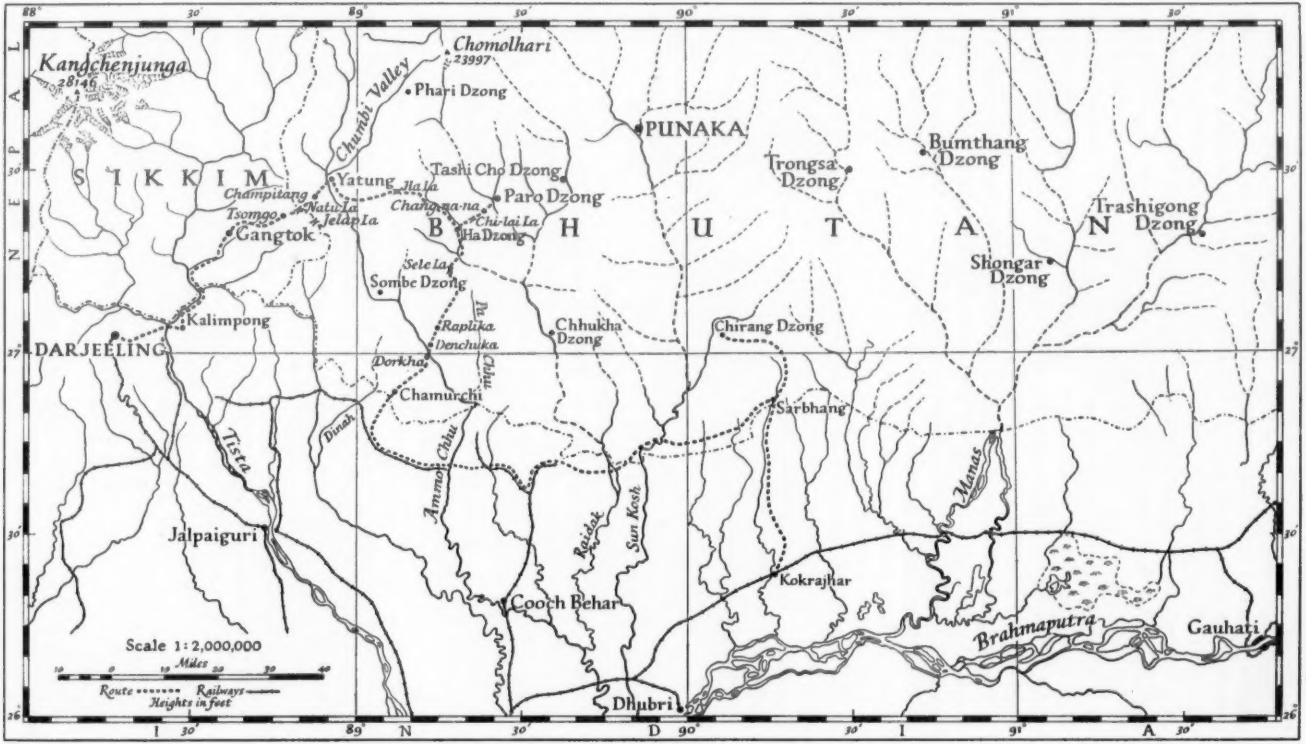
The people of Bhutan are closely akin to the Tibetans and speak a Tibetan dialect similar to that spoken in Sikkim.[1] Anthropologically they are closely allied to the Mongoloid tribes of Nepal, such as for instance the Gurungs, Rais, and Limbus; but whereas the latter are now Hindus the Bhutanese are Buddhists. A very large number of people spend most of their lives in monasteries or nunneries, and probably in no other Buddhist country is such a large proportion of the population so segregated. These religious institutions vary in size from diminutive wayside chapels housing no more than a bare half-dozen monks to the great Lamasery at Tashi Cho Dzong, which contains some three hundred.

Beyond the guards for the defence of the various castles there is no army, but some parts of the country are famed for the manufacture of muzzle-loading guns and swords of highly-tempered steel.

His Highness keeps an agent at Kalimpong, who is also assistant to the Political Officer in Sikkim for Bhutanese affairs. This is at present Raja Sonam Tobgay Dorji. He it was who made the detailed arrangements for my journey and he also gave me much valuable information about the country. I cannot sufficiently thank him for all that he did on my behalf.

Bhutan is probably the most closed country in the world at the present day, and beyond occasional ceremonial visits to the Capital by the Political Officer in Sikkim very few Europeans have been allowed to enter the country. I visited Bhutan in 1933 at the request of the Government of India and at the invitation of the Maharaja. It was originally intended that I should confine my travels to the southern parts of the country, now almost exclusively occupied by Gurkha settlers from Nepal. I was however extremely anxious to see Ha and Paro. There seemed at one time little chance of this: but Mr. F. Williamson, the Political Officer, mentioned my desire to Raja Dorji, with the result that I was given permission to visit both these most interesting places. Part of my route has been previously traversed, but in the opposite direction, by Lord Zetland (then Lord Ronaldshay) when he was Governor of Bengal. "The greater part of the route we followed," he later noted, "was said never before to have been traversed by a European. It provided little of

[1] See *e.g.* 'Linguistic Survey of India,' vol. 3, part 1, pp. 129 *et seq.*


Kanchenjunga
28146
Chomolhari
23997
Chumbi Valley
Phari Dzong
PUNAKA
Bumthang Dzong
Trongsa Dzong
SIKKIM
Yatung
Tashi Cho Dzong
Champitang
Tsomgo
Nathu La
Jelap La
Gangtok
Ha Dzong
Paro Dzong
Chang-ga-na
Chi-lai La
BHUTAN
Trashigong Dzong
Shongar Dzong
Sele La
Sombe Dzong
Kalimpong
Raplika
Denchuka
Chhukha Dzong
Chirang Dzong
DARJEELING
Dorkha
Chamurchi
Sarbhang
Tista
Dinak
Ammo Chhu
Manas
Jalpaiguri
Raidak
Sun Kosh
Kokrajhar
Cooch Behar
Brahmaputra
Gauhati
Dhubri
Scale 1:2,000,000
Miles
Route
Railways
Heights in feet
NEPAL
INDIA

interest, however, climbing up and down heavily wooded mountain sides sparsely populated for the first few days, but colonised by Nepalis as we got nearer to the plains." [1] I have quoted his words as a warning of what follows, since the remainder of this paper is principally concerned with the question of Nepalese settlement in Bhutan. I must also make it quite clear that since my time in Bhutan was fully occupied I had no opportunity, nor had I the means, of making detailed investigations. The journey occupied in all only a few weeks, and I was almost constantly on the move. I would, then, ask the reader to receive my comments in the spirit in which they are offered: that is to say, as the superficial impressions of a very hurried and brief visit.

It is said that until some sixty years ago the foothills about Sarbhang were peopled by Bhutanese. About 1870 however the Bhutanese are believed to have begun a gradual movement farther into the hills. Until a few years before the Great War the district, which consisted for the most part of dense jungle, appears to have been practically uninhabited; but about 1910 the first of the Gurkha settlers arrived. Prior to this however many Gurkhas used to make annual visits to the district, but they never stayed more than a few months in the hot weather. They came in order to tap the rubber trees, of which there is still a large number, but for the rest of the year they remained at their homes in Nepal. This rubber tapping went on for some years, but eventually the Government of Assam commenced to plant on a large scale, after which it was no longer profitable to the Gurkha owing to lack of proper equipment and ignorance of scientific methods. The systematic settlement and commencement of agriculture by Gurkhas in this part of Bhutan appears to date from this time.

There are several reasons for this immigration into Bhutan. Some men for instance told me that in 1914 there was a very serious landslide in the Yangrup district of Eastern Nepal. Large numbers of people lost their entire property in this calamity, and hearing that there was good land to be obtained for the asking in Bhutan they decided to emigrate. Nepal however is undoubtedly over populated in its more fertile parts, and it appears always to have been difficult to arrange for sufficient land in the hills to support the needs of the people. Until comparatively recently the Nepal Terai was of little use as a settlement area owing to the difficulty of providing a sufficiency of pure water and to the danger of malaria throughout the greater part of the year. Thanks however to modern methods of research and to the efforts and expenditure of vast sums of money on the part of successive Maharajas of Nepal, large tracts of this once ill-famed stretch of country have been made habitable and numbers of the early settlers have now been able to return to their own country.

Gurkha settlement in Bhutan is at the present time confined to two main areas: firstly, the eastern area known as Chirang, which lies immediately to the north of the eastern or Assam Dooars; and secondly, the western area, which lies to the north of the Western or Bengal Dooars. This is known to the Bhutanese as Samchi, and to the plains-dwellers as Chamurchi. The two areas are roughly separated by the Sun Kosh river. I decided first to visit the eastern area.

[1] 'Lands of the Thunderbolt—Sikkim, Chumbi, and Bhutan,' London, 1923, p. 246.

Typical Bhutanese

Typical Nepalese settlers

Typical Nepalese settlers

Chirang is reached *via* Kokrajhar, a flag-station on the Lalmanir Hat–Gauhati section of the Eastern Bengal Railway, and here I found myself towards four o'clock of a morning in March 1933. It was hardly the most suitable hour to arrive at even the most civilized of places, nor was I feeling disposed to hunt for a guide. There was nothing to be done beyond spreading our bedding on the cement platform and waiting—one could hardly sleep—for the day to dawn. Later on we learned that the Bhutanese authorities had most kindly sent porters for our onward journey, and soon after daybreak we set off over the dusty and scorched plains: far away in the distance the outline of the foothills was just visible.

Along the whole of the southern border of Bhutan and extending for some miles south into British territory runs a dense belt of forest. This is strictly comparable with the Nepal Terai and is equally famed for the quantity of big game to be found within its secluded glades; and also for the numbers of particularly malicious mosquitoes which make the area uninhabitable for a great part of the year. There are clearings in this forest belt, many of them very large, and before reaching the foothills we passed through a number of villages, occupied mostly by a tribe known as Mechi. The Mechis are of Mongoloid appearance, and except for the very dark colour of their skin, not greatly different from Gurkhas. Many of the men indeed spoke Nepali, but I was told that the women never learn this language. Unlike the Gurkhas, the Mechis carry their loads slung from a pole across the shoulder and do not use the head-strap—the universal method of carrying loads in Nepal. We saw also a few villages inhabited by Santals. These people are small of stature, very dark-skinned, and of somewhat Negroid appearance, but for lack of a common language I was unable to converse with them.

We were forced to spend one night in the forest, where there was a tiny rest-house and a few wretched huts. The people here looked emaciated and fever-ridden. It was a hot and airless night and the glade was filled with the myriad lights of fireflies. Soon after leaving this little clearing of Patgaon the forest becomes denser, and for the last 18 miles or so consists of almost impassable sal jungle. It is crossed only by a few rough tracks, and there is water at only one place. Shortly before reaching the Bhutanese frontier the forest becomes thinner and there is again a number of clearings. During the monsoon rains this forest belt becomes almost impassable, but the journey down from the hills is at all times a fairly arduous one. It is important to note these facts, for they have done much in preventing culture contact with the plains of Bengal and Assam, and have enabled the Nepalese to live a life in conditions not dissimilar to those prevailing in their own country. The Nepalese settlements are equally segregated from the north, as will be noted in a later paragraph.

A mile or so beyond the frontier is a big clearing in the forest, and here is Sarbhang, the principal and indeed the only market for the people living in the Chirang district. It consists of about forty thatched huts, all occupied by Nepalese. The inhabitants live here throughout the year and rice is grown in the surrounding fields. Every Sunday throughout the year a *Hāt*, or market, is held and practically the entire adult population of the district regularly attend. They bring down oranges, potatoes, mustard, and a certain amount

of rice from the hills. These they sell or exchange for salt, which is unobtainable in the hills. I also saw many stalls where cheap cotton goods, necklaces, and mirrors could be obtained, and there was a brisk sale in umbrellas. Oranges are obtainable here at one hundred for eleven annas (about one shilling), and the market rate for rice at the time of my visit was 36 lb. for one rupee (one shilling and sixpence). Most of the oranges are exported by Bengali traders who either visit or have agents in these various markets. Chirang, which gives its name to the district, is about 5000 feet above sea-level. It is only one of many villages, but the name is used to denote the whole of the settlements in this area. There are said to be about one thousand houses in Chirang, exclusively occupied by Nepalese, and beyond the Bhutanese official who accompanied me I saw none but Gurkhas in the whole area.

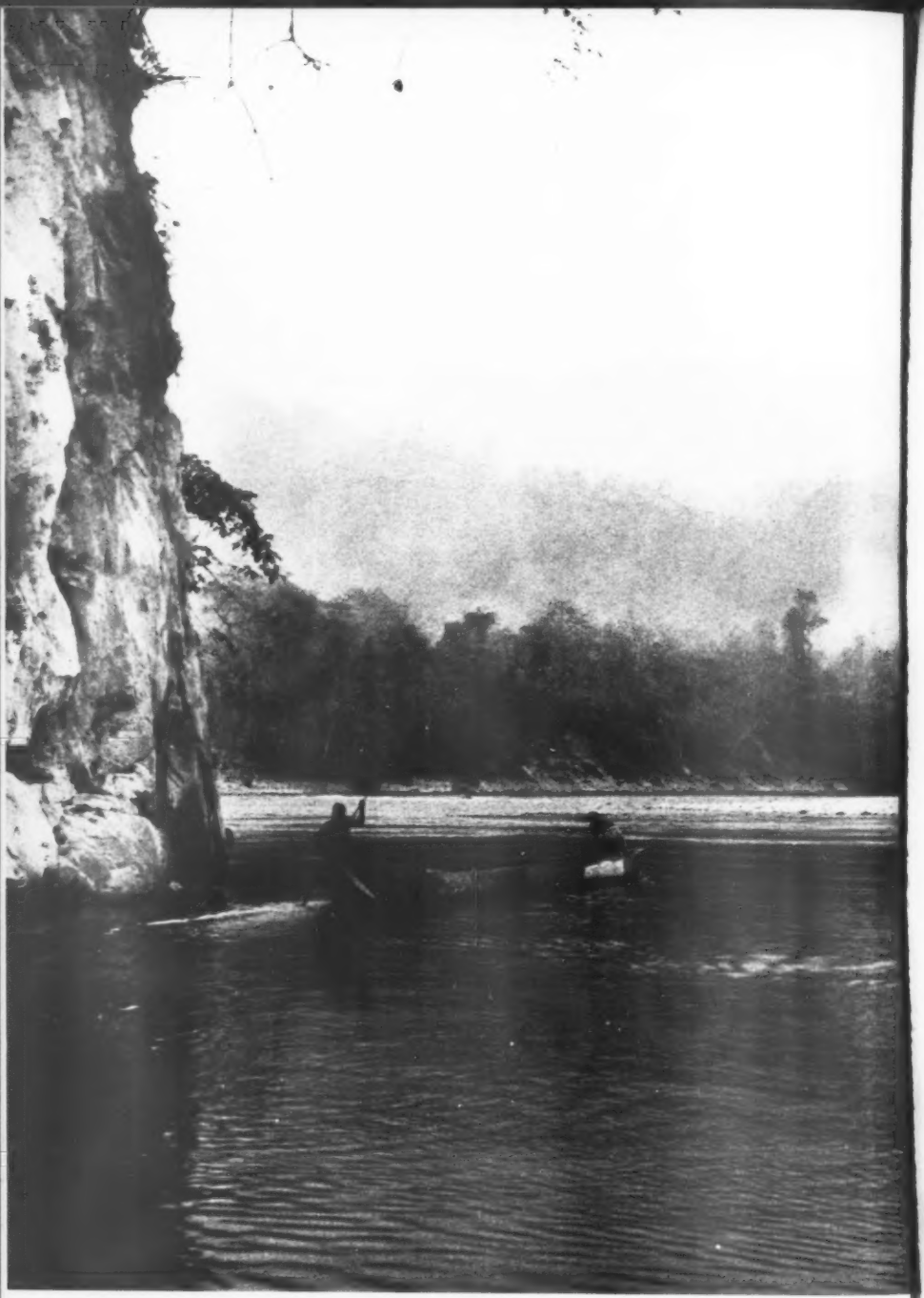
The Bhutan Government does not in any way interfere with its Nepalese settlers, and provided they pay their taxes they are entirely free to live as they wish. It follows therefore that the system of village administration which has gradually come into being is based on that existing in Nepal, only slightly modified to suit local conditions. Each group of villages has an official known as *Mandal* (in Nepal *Mukhiyā*). The Mandal is selected by the villagers themselves and is then recognized by the Bhutan Government. He receives no official remuneration, but, on the other hand, he is not required to pay any taxes. The occupants of each house are required to pay him a tax of one rupee and four annas yearly, or in lieu provide six days' labour. Most people provide the labour and the cash is seldom paid. When labour is required by the Government it must be provided, but is paid for at the rate of four annas a man each day. Each house is assessed at a rate varying between six and nine rupees a year according to the number of male occupants. Buffaloes are taxed at the rate of two rupees a year; cows at twelve annas; and sheep at two annas. All other animals are free. The rent for land under rice cultivation is three rupees per acre yearly; but ground used only for the cultivation of maize is free of tax. All lands are held in perpetuity.

Except in the rice fields the system of cultivation known in Assam as *jhuming* is carried out. In this method a piece of ground is cleared of jungle, used for one season, and then allowed to revert to jungle again for the next four or five years. Large areas are thus being gradually deforested, and much valuable timber destroyed; but it is probably not economically possible under present conditions to carry out scientific timber cutting. Mr. J. P. Mills informs me that it is now generally considered that the custom of jhuming as carried out in Assam is no longer harmful owing to the fact that virgin jungle no longer exists in that district. The same cannot be said at present of Bhutan. It is of course a difficult matter to control; but the Bhutanese Government has made a start by prohibiting all cultivation in the actual valley of the Sun Kosh where jhuming operations on the banks, resulting in some places in almost complete deforestation, had already caused considerable damage during times of flood.

The area in the foothills nearest to the plains is occupied for the most part by a floating population of Nepalese. These grow rice and maize: a few people, those who are able to afford cattle, also grow a little jute, for this cannot be satisfactorily grown without manure. The inhabitants of this district usually

A typical example of Nepalese terraced cultivation

A typical example of jhuming cultivation



Crossing the Sun Kosh river

stay only long enough to make a little money, generally two or three years, and then move on elsewhere. It is from this area that many people have recently returned to the newly opened districts in the Nepal Terai. The whole of this district is very malarious and the people looked ill and under-nourished. One effect directly attributable to the custom of cultivation by jhuming is that the people do not trouble to build themselves proper houses and live in very primitive shelters of bamboo and grass. These last only a short time, but can be easily constructed without cost each time the family moves to a fresh area. The land here is good for rice and maize, but the people suffer greatly from the depredations of wild elephants, which are numerous in the surrounding forests, as also are tigers. I was told that every year four or five people are killed by elephants. Each field has a very high machan in the corner in which people sit up all night when the crop is ripening. It is their custom to discharge a gun at intervals throughout the hours of darkness in order to scare away elephants. In this district there are many so-called salt springs, which are actually large patches of very damp greyish-black earthy sand. The salt is of no use for human consumption, but the places are much frequented by animals as salt licks. We passed by one which contained all about it the footprints and droppings of many kinds of animals, including elephants. I was told that on dark nights elephants can always be heard at the salt licks, but they are said never to come when there is a moon.

The early emigrants from Nepal settled almost entirely in this foothill area owing to the fact that it was the most convenient for their rubber-tapping operations. It was only when the rubber tapping ceased to be profitable and the need for agricultural land arose that they started to penetrate farther into the hills. I do not think the question of the Bhutanese being pushed back by the Nepalese has ever arisen. Raja Dorji himself told me that the Bhutanese have been consistently decreasing in numbers for a very long time. He considered this to be due to the fact that an unduly large proportion of both sexes enter religious institutions and do not therefore marry, and also to syphilis, which is said to have increased greatly during recent years. When the Nepalese settlers started to penetrate into the hills they found them already uninhabited or at least deserted, and even at the present day there is still a fairly wide strip of practically uninhabited land between the two peoples, which both however use as a grazing ground.

One interesting social fact may be briefly noted. When the early settlers arrived from Nepal they left their wives at home, as seems usually to be the case with emigrants. In the course of time however women settlers also arrived, and from amongst these many of the earlier arrivals selected wives. Later on, the original wives, finding that their husbands did not return, decided to join them in Bhutan, and thus it is common for the Nepalese settlers to have several wives. Polygamy is of course permitted in Nepal, but in actual practice amongst the peasantry monogamous marriages are by far the more common, except where there have been no children by the original marriage.

At one place we were shown a Limbu cemetery. There were no longer any survivors of these particular settlers from eastern Nepal. The Headman pointed out that the people had made a particular point of burying their dead with the faces turned in the direction of Nepal, whence they had originally

come. He also told me that if the deceased had been a heavy drinker or smoker it used to be the custom to place a little spirit or tobacco by the side of the grave; but with the death of the last of this particular colony the custom had not survived. Each grave was marked by a pile of stones, but there was no indication of any names.

After crossing the Sun Kosh river I re-entered British territory; but the subsequent journey across to the western or Chamurchi area, carried out by various means of transport, does not merit description here.

The Chamurchi or Samchi district of Bhutan lies directly to the north of the tea-growing district of Jalpaiguri. Unlike the eastern district this area is not approached through dense forest as the land was cleared and turned into tea plantations many years ago. It was indeed on account of the ease with which work could be obtained on the tea gardens that the early Nepalese settlers came to this part. Amongst the earlier arrivals was one with considerably more foresight than his fellows. He discovered that there were vast quantities of lime to be obtained with ease in the surrounding foothills of Bhutan; and in course of time he obtained the sole right to deal in this commodity. His enterprise flourished considerably until later on he was able to obtain a concession for practically the whole of the western area now occupied by Nepalese. No actual boundaries have been fixed, but the concession appears at present to be bounded on the east by the Pa Chhu river and on the west by the Dinah. The southern boundary is of course the British Indian frontier; and the northern extends as far as Raplika, a grazing camp one march beyond Denchuka. The present holder of the concession is a grandson of the original owner. He holds his title on the authority of the Maharaja's *lāl mohor*, which has been granted to him and his successors in perpetuity. Since he has been invested with full judicial powers, excluding only the power to award a sentence of death, and is required to remit only a portion of his revenues to the Bhutan Government, his position is somewhat analogous to that of a tributary raja to the Maharaja of Bhutan. The system of administration does not differ greatly from that in force in the eastern area; but if a settler wishes to leave the district his land and houses lapse to the owner of the concession, who is at liberty to sell them to any one he wishes. Taxes are rather higher than in the other district; but since the area has been settled for a longer period the land is probably much more valuable. This corner of Bhutan is said to be much used as a refuge by Nepalese criminals when they are able to get away before the discovery of their crimes. Incidentally, it may be of interest to note that in Bhutan the death sentence is carried out by sewing the criminal up in a bullock skin and throwing him thus into the nearest river: it is said to be most efficacious in preventing crime!

In the Samchi district there are now many Brahmans, mostly of the Jaisi sub-caste. The Brahman is as a rule thrifty, and neither drinks nor gambles. The Mongoloid tribes, on the other hand, have no such scruples, and are extremely improvident: when they have any money they like to spend it. The result of this state of affairs is that most of the Gurkha settlers are heavily in debt to the Brahmans, whose position in Bhutan, unlike Nepal, is no longer that of spiritual leader but of money lender. Their position is analogous to that of the Marwaris in the plains of India. Cash advances are usually given

against a lien on the harvest, and the rate of interest is high. Brahmans, on account of their superior social status, used formerly to receive homage from every one, as indeed they still do in Nepal. In Bhutan however this custom has entirely dropped out and they are not now treated differently from any one else. Many Bhutanese also advance money to Nepalese settlers for grain. The rice and other crops grown in the Dorkha–Denchuka area is much more than is required for the people's own consumption, and large quantities are therefore sent up into the interior of Bhutan, notably into the Ha district, where, on account of its elevation and consequent cold climate, rice cannot be grown. Some of the Nepalese in the areas nearest the plains have now taken to breeding pigs on quite a large scale. These they dispose of at the weekly markets where there is a big demand for them by the agents of the various Calcutta hotels.

It was my intention after visiting Samchi to continue north to Ha, and then, after visiting the Governor of Western Bhutan at Paro, to return to India *via* the Chumbi Valley and Sikkim. I stayed some days at Samchi both in order to pay my respects to Kaji Hemraj Gurung, the present owner of the concession, and also to make arrangements for the onward journey into Bhutan proper. It was a characteristic kindness of the Paro Penlop to send me a letter of welcome to this place: he told me that all arrangements had been made for my visit, but gave me no hint of the part I was expected to play.

We set off towards the end of March: it was already almost unbearably hot in the plains, and I was glad, in spite of the roughness of the track, to be making for the inner heights. Along the whole of the southern border of Bhutan the foothills rise very steeply and suddenly out of the plains, and there is not such a gradual ascent as in other parts of the Himalaya. It follows therefore that the valleys are narrow and steep and the rivers in consequence swift. To these facts are due the peculiar Dooar formation to which reference has already been made, and which makes it difficult to enter the country except through these various narrow valleys. The Chamurchi Dooar, through which we now entered, is formed by the valley of the Ammo Chhu and is a remarkable natural gateway and a very strong defensive position. It was in this area that the operations against the Bhutanese took place in 1865, and it is not difficult to realize what a very great advantage must have been possessed by the defenders.

There is no proper road up the valley of the Ammo Chhu, but we were easily able to pick our way along the boulder-strewn banks. I had been given a mule to ride and was told that his name was *Gyamo*, or "The brown one." His master, a Nepali-speaking Bhutanese, kept up a running commentary as the mule picked its way carefully amongst the rocks. "Now then, Gyamo, go carefully!" he would say, "don't stumble; go round that rock; go slowly, don't throw the gentleman off!" and so on. But in spite of these careful injunctions Gyamo, who was a quiet and tractable beast, did manage on one occasion to pitch me over his head, but without any damaging result. As we descended the hill towards Dorkha, the chief stronghold of the Nepalese settlements, we were met on the path by a party of Damai musicians, who played us into the village. Every now and again the band would halt while the leader, who carried an enormous jointed instrument, blew a sort of

fanfare. Occasionally he would execute a brief *pas seul* in front of the band. In this manner we proceeded at a slow pace for the last mile or so.

I found on arrival at Dorkha that my visit had been made the occasion for a general gathering of the surrounding villagers. The place had been gaily decorated and I found that I was expected to make a speech to the assembled headmen. It was a great pleasure to meet them; but since I was travelling very lightly and quite unprepared for anything of the sort, the official part of the gathering was a trifle embarrassing. I hoped that there would be nothing of the kind at Paro; but in any case there was now nothing to be done, since I was quite out of touch with India and could make no further additions either to my following or my wardrobe.

Dorkha is largely populated by Rais: Denchuka, on the other side of the river, by Limbus, both these being eastern Nepalese tribes. All the rice fields here were beautifully terraced and the houses well built of stone with thatched roofs. Jhuming is not the custom here, and there is therefore more incentive to build permanent houses. The people were very cheerful and seemed prosperous, and everywhere I was greeted with the greatest kindness and attention. When the rice is cut it is all collected in one spot, known as *Khali*. Both Rais and Limbus spread the sheaves all over the ground in this place and then both boys and girls dance on it in order to separate the straw from the rice. This is a time of great feasting, and singing and dancing go on throughout the night.

In Nepal, although at one time most of the Mongoloid tribes were in the habit of burying their dead, the custom of cremation is now becoming usual owing to the spread of orthodox Hindu ideas. In Bhutan however both Rais and Limbus still bury their dead and there is a small cemetery outside each village. Only very occasionally are bodies cremated, in spite of the fact that fuel is plentiful here: this is only one of many possible examples which might be quoted to show how the customs of an emigrant people persist in spite of changed geographical conditions.

In addition to the Nepalese there are also in this district a number of Lepchas, some of whom are Christians, and a very few people calling themselves Daoya. The Daoyas, of whom I saw only one or two, are of very Mongoloid appearance. Some of them speak Nepali, but their own language almost certainly belongs to the Tibeto–Burman group, as I found some words to be almost identical with those used in other languages of this group with which I am familiar. The Daoyas eat elephants, which they kill by means of poisoned arrows. They make their clothes from the fibre of nettles. They have apparently no caste restrictions and no organization beyond that of the family, as in Tibet and Bhutan. They are said to intermarry to some extent with the Bhutanese. The Daoyas never burn their dead but place them in very shallow graves, which they cover with large flat stones: offerings are made at the graveside from time to time. These people do not recognize the Brahmans in any way nor have they any priesthood of their own. I have been unable to find any mention of them in works of reference. They seemed somewhat similar to the Naga tribes of Assam, whence they may possibly have originally come.

We left Dorkha as we had entered it, with a musical accompaniment. The

band turned back after a mile or so and almost at once the country became less thickly inhabited. The last Nepalese settlements are at Raplika, north of which the Samchi concession does not extend; but beyond the Bhutanese hamlet of Shektina the area between Raplika and the Ha valley is practically uninhabited. It is thickly forested and contains some good grazing alps. It is used by both the Bhutanese from Ha and the Nepalese from Dorkha and Denchuka as a grazing ground, and I noticed a number of temporary shepherds' huts scattered about on the hillsides. This practically uninhabited tract serves as a buffer or "no-man's land" between the Bhutanese and the Nepalese, and segregates the latter from the north in the same way that the Terai forest does in the south of the eastern settlement area.

Although the hamlet of Shektina contains no more than a dozen or so Bhutanese shepherds it is at once apparent to the traveller that he has entered an area of a different culture. In place of the Nepalese wood and thatch we have here two-storeyed houses with roofs of matting, weighted down with large rocks. The method of cultivation too is different from that practised by the Nepalese, for the millet fields surrounding the houses are not terraced, as they certainly would be were they Nepalese.

Before entering the Ha Valley we had first to cross the Sele La, an easy pass 10,900 feet above sea-level. We climbed up through pastures deeply carpeted with purple primulas and soft green bracken: it was a strange contrast to the steamy forest through which we had passed only a few days previously. There was fresh snow on the top of the pass and a cold wind blew: we halted only long enough to check the height and then ran rapidly down the snow-covered track that leads into the Ha Valley. This valley lies at an average height of 8000 feet above sea-level, and is therefore never hot. The surrounding hillsides are high and steep, so that the valley loses the sun in the early afternoon. During these days of early April it was pleasant when walking about in the sun, but bitterly cold in the early mornings and evening. I have never seen any Himalayan valley that so reminded me of Switzerland—of the road up to Zermatt for instance—and the impression was heightened by the very chalet-like appearance of many of the houses.

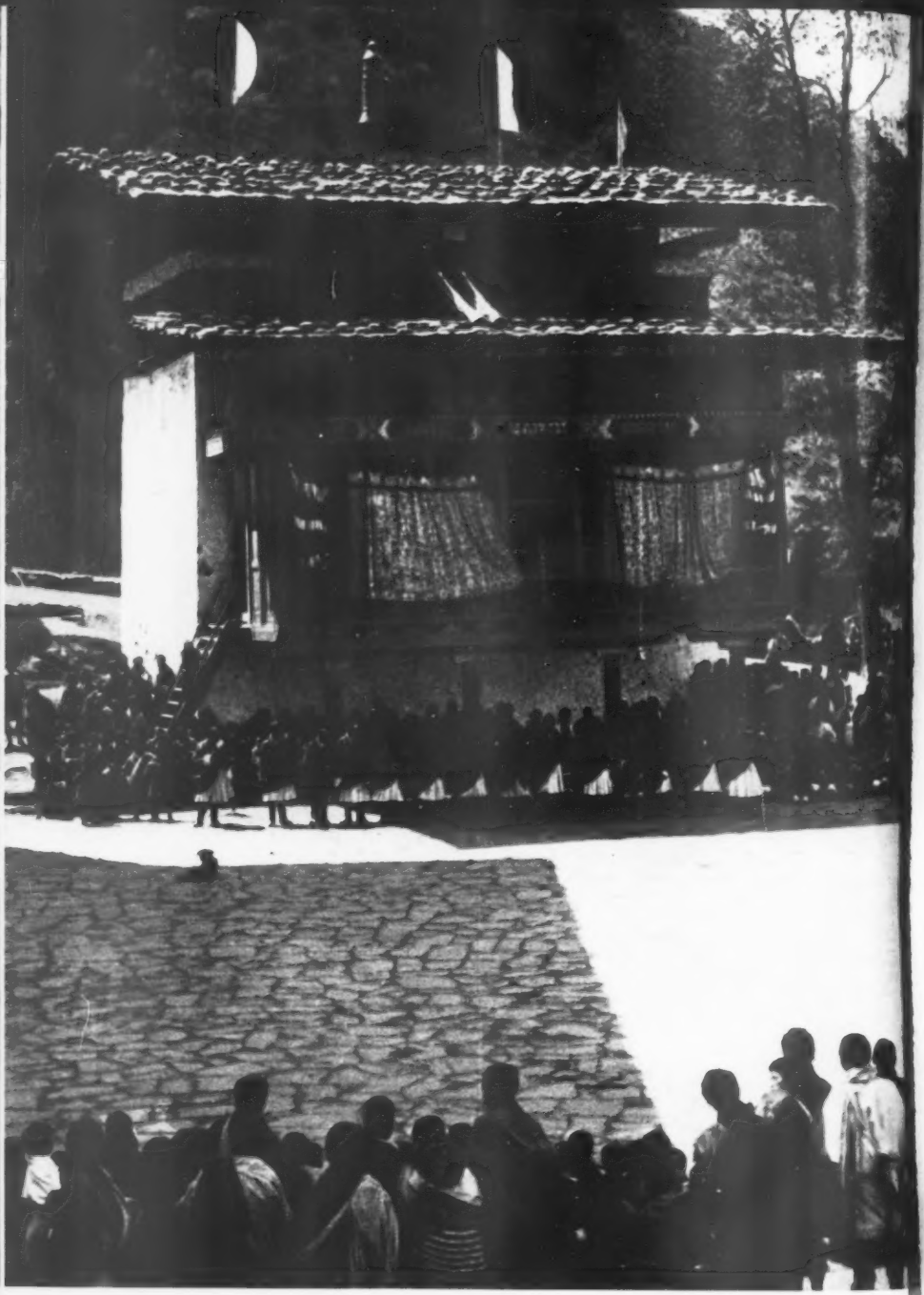
Any doubts I might have had concerning the nature of my visit were now finally resolved, for I noticed with considerable apprehension that the path leading up to Raja Dorji's house, which he had most kindly placed at my disposal, was lined with local officials and schoolboys, who had erected a large banner with an inscription of welcome over the door. I felt that I had come out of the ordeal of speech making rather badly, and my sombre garments compared most unfavourably with the magnificent brocades of my hosts. The Dzongpon however was a man of great charm. He had been educated at the University of Calcutta, and it soon became apparent that the opportunity to exercise his considerable knowledge of English made up for some of the stranger's other deficiencies. Since the Bhutanese are Buddhists and therefore free from the restrictions of caste, we were able to dine together, and thus a degree of intimacy was possible such as would be quite out of the question in most other parts of the Himalaya. The Ha Valley forms part of the personal estate of Raja Dorji, the Bhutanese Agent at Kalimpong, and to him is principally due a remarkable educational experiment which has been

proceeding with the very greatest success for some years. He himself was educated at St. Paul's school in Darjeeling, but he early realized that although Bhutan has need of men with modern western education, it must be an education adapted to the special needs of the country and given primarily through the medium of the people's own tongue. There were some thirty boys in residence at the school, where they are given instruction up to the university matriculation standard. It is hoped that eventually they may be trained to the various professions of which the country has need, such as medicine, forestry, and agriculture. With great foresight the number of pupils has been strictly limited to the number of trained men the country can at present absorb, and during their early training the boys are always in intimate touch with the lives of the people amongst whom their work will eventually lie. It is in this matter in particular that the school gives such a much better education than any provided in British India. The Dzongpon of Ha, who, as I have already noted, was extremely well educated, fully realized that he would have been of more value to his country had his own preliminary training been carried out on similar lines. "I can draw from memory a map of Africa," he told me, "but of what use is this in Bhutan, where my ignorance of agricultural methods is a great handicap?"

In order to reach Paro we had first to cross the Chi Lai La. This pass is 12,200 feet above sea-level, but the ascent is very gradual and presents no difficulty of any kind whatsoever. A number of domestic yak were grazing on the upper slopes, but they resented all efforts to approach them closely. A little way down on the Paro side of the pass the Penlop has constructed a little bungalow at Chang-na-na, and at his special request I arranged to spend the night in this delightful little forest clearing. No sooner had I arrived than the Penlop's representatives were announced. They brought with them a letter and scarf of welcome and a considerable quantity of liquor and oranges, all in heavily sealed containers. We set off early the next morning, the Penlop's retainers making a picturesque addition to my humble retinue. Hardly had we covered a few miles when I found a meal spread out for me by the wayside and a further supply of spirit and oranges. This remarkable display of hospitality was repeated at intervals along the route. I had now sufficient oranges to last me for several months, and the spirit, which I had on each occasion distributed to the assembled company, had put them all into a distinctly Jubilee mood. I was by now so embarrassed by this lavish display of welcome and my lack of ability to make any adequate return that I was quite unperturbed by the state of my following, for, truth to tell, the Penlop's special brew was no fit drink for the hours of the hot mid-day sun! The culminating point however had by no means yet been reached, for a short distance outside Paro itself the Penlop's private bodyguard awaited us. They brought with them a magnificently caparisoned mule for me to ride and also a small portable cannon. We proceeded at a slow pace, the size of our party being increased at each house we passed. At intervals the whole cavalcade was halted while some of the retainers performed a short dance and the ancient piece was primed. I was preparing to dismount before the explosion, but I was told that the mule was well used to the performance: and so it proved to be. I was now taking, so far as I could see, the principal part in a mediaeval

The valley of the Ammo Chhu, showing the entrance to Chamurchi Dooar

The upper reaches of the Ammo Chhu



Lama dance at Paro Dzong

pageant; but by some mischance I was dressed in the inappropriate mufti of the twentieth century, and I felt that some sort of fancy dress would be more suited to the occasion. With some such feelings as these I dismounted by the banks of the river, where I found that a most comfortable camp had been prepared and laid out on a lavish scale.

I decided to call on the Penlop at once in order to thank him for his welcome. Some word of my intention must evidently have reached him, for with true oriental grace he decided to forestall me and pay his visit first. He was perfectly charming and all doubts as to my reception were finally set at rest. He appeared genuinely pleased to meet some one from the outside world, and stayed talking for a considerable time. Before he left we arranged that I should dine with him on the following day and then witness a performance of the dance which annually takes place at this time of the year.

The big dance of the year at Paro is held in the early Spring and usually lasts for three whole days. It is carried out entirely by parties of monks who live in the monastery attached to the Dzong at Paro and must, I imagine, necessitate many months of arduous practice throughout the year, for there did not seem to be the slightest hesitation or mistake throughout the entire performance. Very early in the morning people started to arrive from all the surrounding villages. Most were dressed in their gala clothes in which brilliant reds and yellows predominated; many, with a view to staying throughout the entire three days, carried supplies of food and drink with them. The performance was timed to begin at ten o'clock, and shortly before this hour I was escorted to my place beside the Penlop. The dance took place in an inner court of the Dzong, where was a paved court surrounded on all four sides by many-storeyed buildings, the ground floors of which were built in the form of large verandahs opening on to the court. Privileged spectators and some of the monastic dignitaries were accommodated in some of these verandahs, others were used as dressing-rooms for the performers. There was a dense mass on all four sides and the crowd was in holiday mood. It was probably the first occasion that many of the spectators had ever set eyes upon a European; but it was a relief to be treated with no more attention than an Englishman receives in Piccadilly.

Punctually at ten there was a crash of cymbals and a faded yak-hair curtain was pulled aside. There then entered in slow procession the various officials of the Penlop's court and all the elders of the monastery. All were dressed in magnificent robes of brocade and silk and many of the priests carried large drums which they beat rhythmically as the procession moved slowly round the court. Following them came the dancers, all of them monks or novices, some fifty or so in number. Some were dressed in peacock blue brocades and wore large-brimmed black hats surmounted with a single peacock's feather; others were garbed in costumes of various colours and wore the most fantastic masks. One series for instance represented human skulls; another yaks and cows; and there was one series consisting of the most nightmarish of farmyard animals: one almost expected Alice or the White Knight to appear at any moment. Soon the court was filled to overflowing and all but the actual dancers then withdrew.

We saw first the Black-hat dance. This has been many times described by

travellers to Tibet, where it may be seen in many of the monasteries. It was carried out by the monks in robes of peacock blue. The dance consists in slowly circling round the arena with the addition of a very intricate gyration at every few steps. By means of certain hip movements the dancers are able to keep the very ample folds of their robes standing well out from the body, and there is much graceful play with the long ribbon streamers with which each performer is adorned. This and indeed the other dances too were extremely interesting to watch for a short time; but since each separate movement is performed for about two hours without a break of any sort the spectacle becomes a little wearisome after a time. One would imagine these dances to be extremely exhausting, but in actual fact none of the performers appeared to be in the least tired after dancing in the hot sun for two hours without a rest.

All the dances were carried out to the accompaniment of the monastery band. In addition to several kinds of drums and flute-like instruments there were several very long trumpets. These were not sounded continuously, and their notes appeared often to be in rhythmic opposition to the rest of the music. Their note was extremely deep and more of a pulsating vibration than an actual musical sound. These long trumpets produce only one note: they are said to be difficult to play, and only a man with exceedingly strong lungs is able to produce any sound out of them. In front of the band sat all the novices, many of whom were quite small boys, not more than seven or eight years of age. They were clearly enjoying the performance; but lest they lose sight of the more serious religious significance of the play an elderly monk occasionally brandished a knotted whip in their faces in order to restore their wandering attention. For a little while they would watch the dance with rapt attention, but soon their gaze would be wandering and before long they would once again be laughing and talking amongst themselves.

Other dances followed the Black-hat dance, but there is no space here to describe them. In some the performers were completely masked, in others they wore a head-dress almost exactly similar to the head-cloth universally worn in Arabia. One dance in particular appeared to be connected in some way with the idea of Spring, although none of the people actually offered this interpretation. In this dance, which was free from the stereotyped movements considered essential in the more ritual dances, the performers all wore wreaths of fresh green leaves.[1] The dance was continued without a break until the late evening, and many of the villagers camped in the Dzong for the night.

On the following day the whole performance was repeated. This time it took place in an open space outside the fort in order to allow a greater number of spectators than was possible inside the Dzong to watch the celebration. It was preceded by a dignified procession consisting not only of the Penlop's Court officials but also of the entire population of the monastery; all wore Lama's robes of deep maroon. The purpose of this procession was to do honour to a visiting prelate from Tibet and to escort him in state to the performance. I had no opportunity to talk with him, but he gave me the friendliest of smiles as he passed to his seat in the upper storey of a neighbouring house. From this point of vantage he watched the dances from behind a thin gauze

[1] Cf. *e.g.* 'The Golden Bough' by Frazer, abridged edition, ch. 28, pp. 296–323, inc.

screen. Once more the dance was continued throughout the day, and only when the sun had already sunk behind the distant hills did many of the spectators set off towards their homes. Late that night I went for a last turn along the banks of the river. The walls of the Dzong gleamed white in the cloudy moonlight, but there was no lamp in any of the windows. From somewhere far above in an upper gallery I could hear the piercing vibrations of the longest trumpets: evidently the last office of the day was being celebrated. Soon there was no further sound, only the plash of the water against the stones in the river-bed. I turned and went back.

After leaving Paro I retraced my path to Ha and from the latter place crossed over the Ha La (13,900 feet) to Chumbi. Although it was now mid-April it was bitterly cold in Yatung and a little snow fell. I decided to push on into Sikkim, waiting only long enough in Chumbi to collect transport. The road from Chumbi over the Natu La to Sikkim is almost a tourist track, and has been traversed by hundreds of travellers. It was raining when we left Yatung and still exceedingly cold. Very soon the rain turned to snow, and it was only with difficulty that we reached Champitang late that evening. It continued to snow, and by the next night there was about 4 feet all round the bungalow. It seemed impossible to go on, but after two more days we decided to try the pass, as the supply of food for the transport mules was running low. We set off in almost a gale, and it was impossible to see for any distance in front. My diary for April 16 notes: "Over the Natu La: left at 6.30 and reached Tsomgo at 5.30 in the evening. Snowstorm most of the way: a tiring day." The following evening we arrived at Gangtok, whence I continued by motor to Darjeeling.

DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: My Lords, Ladies and Gentlemen,—Major Morris, who is going to read the paper to-night on "A Journey in Bhutan," is no stranger to us. He lectured to us twice in the Aeolian Hall: in 1923 on "A Journey in Nepal," and in 1928 on "A Journey in Hunza–Nagar Territory," while at the opening of this hall he was one of those, as a member of the Second Mount Everest Expedition, to speak on the platform here. He is a practised lecturer and a highly skilled photographer, so you may be sure that we are going to have an interesting evening. The journey he will describe was undertaken in March 1933. He is shortly going back to India, to Nepal, and the Himalayas, so we may look forward to hearing him again later on. To-night, as I have said, he is going to talk about Bhutan.

Major Morris then read the paper printed above, and a discussion followed.

The PRESIDENT: Lord Zetland, the lecturer has made reference to your connection with the region: I hope you will favour us with some observations on the expedition undertaken by you in the tract of country he has been discussing, during your service as Governor of Bengal.

The MARQUESS OF ZETLAND: I need hardly say that I have listened to Major Morris's paper with very acute interest, for I have travelled over much of the ground which he has described to us to-night. I have witnessed those remarkable corybantic performances at Paro Dzong of which he has shown a number of most admirable pictures. I have taken part in those ceremonial processions which the hospitable people of Bhutan insist on organizing in honour, if I may

say so, of distinguished visitors, and I have drunk, as Major Morris drank, the wine of the country.

Those of you who have visited Sikkim will perhaps remember that the wine of the country, known as *marwa*, is made by pouring hot water into a vessel containing fermented millet. The hot water can be poured into the same vessel of millet more than once, and at first sight it might be mistaken by the novice for a temperance drink. The question whether indeed it did come within that category or not was settled rather unexpectedly one day for me and my companion—an ardent teetotaller, by the way—who were drinking *marwa* provided by the hospitable headman of a Sikkim village. We got into conversation and asked: "How many times may the vessel of millet be replenished with hot water?" and they replied, "Oh, many times." We then asked, "What is done with the millet when it is finished with?" and we were told that it was given to the pigs, and our informant, looking at us reflectively, added musingly and, if I may say so, quite gratuitously, "And the pigs get drunk too."

Major Morris has spoken of the unhealthiness of the Dooars, that undulating country which runs along the borders of Bengal and the mountain States, including Bhutan; and it is, indeed, a fever-infested land. In the plains of Bengal the malaria carrier is the mosquito known as *Anopheles fuliginosus*. The *Anopheles fuliginosus* breeds only in stagnant water. One might have hoped therefore that when one came to the undulating tracts of the Dooars where water is not stagnant but where there are running streams, one would have got beyond the range of the malaria-carrying mosquito; but, unhappily, there is another mosquito, the *Anopheles listoni*, which also carries the malaria parasite, and by an unhappy dispensation of Providence this mosquito breeds not in stagnant but in running water! Hence the malarious nature of the Dooars.

But it was not by the Dooars that I myself entered Bhutan. I actually entered the country by a route which lies a good deal north of the Ha La by which Major Morris told us he left Bhutan to enter the Chumbi valley. I actually branched off from Phari on the Phari table-land and crossed into Bhutan by a pass known as the Tremo La, some 16,500 feet in altitude, dominated in its turn by a magnificent snow-clad peak known to the Bhutanese as Cho-tra-ké, "The Lord of the Cleft Rock," and proceeding down the Pa Chhu, that is to say, the Pa river, I came to Paro.

Now there are two things that immediately strike one in Western Bhutan. The first of these things has been well brought out by Major Morris in the course of his paper, and particularly by his photographs. That is the solidity and the massive character of the chief buildings of Western Bhutan. The first time that I crossed the Pa Chhu I did so by a substantial covered-in roadway similar to the one of which Major Morris showed a photograph, flanked by stone towers at either end and constructed with great engineering skill, as it seemed to me, on the cantilever principle.

Some way down the Pa Chhu I came across that which is reputed to be the oldest of the great feudal castles of Bhutan known as Duggye Dzong, and I found structures which corresponded very closely to the barbican, the gateway, the bailey, and the keep of feudal castles of the twelfth century of our own country.

And that brings me to the second point which immediately, I think, strikes the traveller, and that is the existence in Western Bhutan of a social system which corresponds very closely, as far as I was able to judge, with the feudal system which was characteristic of a well-known epoch in our own history. The Duggye Dzong itself is a vast building, but even Duggye Dzong pales into insignificance before the immense dimensions of Paro Dzong, of which you have seen photographs this evening, a really stupendous quadrilateral of whitewashed stone,

with the great eaves of a penthouse roof surmounting it. At the time of my visit I was informed that the actual population of the castle of Paro Dzong itself was three hundred persons. The impression that I had stepped back in time to the twelfth century in our own country was heightened by an archery contest which was ordered by the Penlop, or governor, of Western Bhutan in my honour. Locksley had his counterpart in a skilled bowman who had come from a distant part of Bhutan to take part in the contest. The targets were set up at each end of a pitch about 120 paces in length, and it was the practice of the archers, as soon as they had discharged the arrows from their bows, to shout after them wildly adjuring them to fly true to the mark. I soon noticed that this practice was very necessary, though on this particular occasion it, unhappily, did not prove to be very effective. However at last one archer did succeed in getting a bull's-eye, much to the delight, and I think the surprise, of the vast audience which had gathered round, and the proceedings came to an end with the falling of dusk.

From Paro I traversed the same route as has been described by Major Morris this evening, only of course in the reverse direction, spending some time at Ha, the Bhutanese home of Raja Sonam Tobgay Dorji, the admirable Bhutanese Agent, through whom passes all the official correspondence between the Government of Bhutan and the Government of India. I should like to join Major Morris in the tribute which he paid both to the charm and the ability of Tobgay Dorji.

I was delighted to hear what Major Morris said with regard to the educational experiment which Tobgay Dorji was actually initiating at the time of my visit, and I remember well the enthusiasm with which the scheme was conceived and with which its details were worked out, on the advice of Drs. Graham and Sutherland of Kalimpong.

From Ha I crossed back down the route across the Nepali inhabited part of Southern Bhutan over the same route as that by which Major Morris entered, returning to Bengal once more by, I think, the same Dooar—at least judging by the photograph it appeared to be the same—the Chamurchi Dooar, of which you saw a picture.

May I say once more how very much I have enjoyed listening to the lecture which has brought back to me so many memories of a happy kind.

The PRESIDENT: Ladies and gentlemen, we have been indeed fortunate in that Lord Zetland has been able to be with us to-night. I am sure I am voicing your feelings when I say what a great pleasure it has been to us to see him on this platform. We only wish that we saw him oftener.

There is one question I would like to ask the lecturer. He said that the masks shown in his pictures seemed to be of Chinese origin. I do not know whether he has been on the Leh side of Tibet, and, if he has, whether he regards them also as being of Chinese origin. I have always regarded them as Tibetan.

Major MORRIS: I think they are rather different.

The PRESIDENT: I take it the local idea is that the masks came from China. I do not know that we have any other speakers present to-night who know the country that we have been hearing about; in that case I can only ask you to join me in thanking the lecturer. It has been of very great interest to listen to him and see his fine photographs, especially the different types met with. They must be of very great value. Major Morris' bent is in the direction of anthropology, and during his journeys in Nepal or, as in this case, Bhutan, he devotes himself especially to anthropological work among the natives. I ask you to join me in thanking him exceedingly for his excellent paper and his very fine photographs.

THE HAGAVATN GORGE: *A paper read at the Afternoon Meeting of the Society on 20 May 1935, by*

JOHN WRIGHT

IT is reasonably certain that the whole of Iceland was covered by a single ice-cap during the Quaternary glaciation (27, 28), and there still persist relics of this in the form of small ice-caps on the high ground (Map 4). On the whole these are retreating, though they are subject to minor advances from time to time. One result of this is that there are many small lakes at the edges of the ice-caps, due to the almost complete absence of any drainage system in the recently exposed ground. Several of these are ephemeral, and especially round the Vatna Jökull there have been reports of lakes which existed in the last century and have now vanished (25, 31).

Often one shore of such a lake, or a small part of the shore, is formed by a glacier, and in such cases they are particularly subject to variations, and sometimes are the cause of serious floods (22, 27–30). Hagavatn has been known (26) for some time as such a lake, and at least three floods are known to have been due to it: in 1884, 1902, and 1929. The last one was particularly noticeable, for two reasons: first, because it swept away much of the stacked hay in the fields near the outlet river, and so caused considerable loss to the farmers; and secondly, because it resulted in the formation of a new fall. This was named the Leynifoss, or hidden fall, by Herra Óláfsson, the Icelandic surveyor, because the crooked nature of its gorge conceals it from a distant view.

Fortunately two Englishmen, Mr. C. R. Roberts and the Rev. George Seaver, were in Iceland at the time and were able to visit the fall within two days of its birth, which occurred on 16 August 1929. They wrote an account for *The Times* which appeared on September 13 in the same year, and in March 1930 Mr. Reynolds wrote a short account in the *Geographical Journal* summarizing their results and illustrated by two excellent photographs taken by Herra Tryggvi Magnússon, of the Hekla Tourist Bureau, a fortnight after the birth of the fall (24). The lake was visited in 1930 by Mr. B. H. Humble with three friends, but only general observations were made (6). It was suggested then that a full investigation should be made together with a large-scale survey, as the Danish survey only covers the southern end of the lake (34, 35).

1934 *Expedition*

The present expedition was therefore organized last year to make a large-scale map of the lake, sound it, investigate the condition of the glacier, and estimate the probability of another flood in the future. It was also intended to map the ice-cap edge on a smaller scale, and cross it in order to make a section by aneroid heights. However owing to bad weather there was not time for both of these objects, and the former was thought more important. Three members of Cambridge University formed the personnel: S. White, of Emmanuel, geologist and surveyor; H. J. Simpson, of Trinity, surveyor; and the writer, also of Trinity, leader and geomorphologist. I should like to express my thanks to the others for the help they gave me. A very large proportion of the observations was due to them.

This Society was kind enough to lend instruments and support the expedition officially, and a grant of £20 from Trinity College together with gifts from firms, particularly Messrs. Cadbury, Tate and Lyle, Huntley and Palmers, and Kodak, made an extended programme possible. A 9-foot Berthon collapsible boat was very kindly lent by Mr. Wallace, of Emmanuel, and was used for sounding and occasionally for transport. We should like to record our sincere thanks to Brian Roberts, who suggested the expedition, and without whose help and advice it would have been impossible; also to Professor Debenham and Miss Creswick, of the Polar Institute, and to countless friends for help and the loan of equipment. Mr. Lewis and Mr. Wordie were kind enough to read through this paper and make several valuable suggestions. We also owe a great deal to Herra Stefán Stefánsson who organized our transport in Iceland and gave us much useful information, and to his friends Helgi Jónasson and Tryggvi Magnússon, who have provided several of the photographs which illustrate this paper. We travelled by the regular weekly steamer to Reykjavik and thence by lorry and ponies to Hagavatn.

The survey was made entirely by plane-table, on a scale of 1 : 20,000, a base being measured with a 100-foot linen tape, and all heights determined with an Indian clinometer. A map was also made of about 20 miles of the ice-cap edge on a scale of 1 : 100,000, in this case by resection from four of the Danish Trigonometrical stations of which their Geodetic Survey were kind enough to give us the coordinates. All survey instruments, with the exception of a telescopic alidade and two aneroids, were lent by the Geography School, through Professor Debenham.

Topography

Hagavatn lies against the southern edge of the Lang Jökull, which Dr. Nielson has established to be the second largest ice-cap in Iceland (19), being about 12 miles broad by 30 long. The lake is heart-shaped, with the point to the west, and the outlet at the apex of the north-east lobe, while a stream flows in at the western end. It has an area of about $3\frac{1}{2}$ square miles, and before the flood must have been larger by about 10 per cent. It is the lowest of a series of four lakes, all of which lie against the ice-cap edge, and is by far the largest, as the others total less than 3 square miles (Map 2).[1] It is at a height of 1460 feet above sea-level, and is 700 feet below the farthest lake, which appears to be without a name. The other two down-stream are called Langvatn, at 1650 feet, and Sandvatn, at 1500 feet respectively. There is also another Sandvatn below the fall at a height of 900 feet, but this, although it feeds the same river, the Tungufljót, is outside the system proper, as it is not a glacial lake, and so is not subject to the same influences. It is unfortunate that there should be two lakes so close together with the same name, which is due in both cases to their being surrounded by sand deserts.

The north-west shore of Hagavatn (Map 1) may be divided into three parts, which are approximately equal in size. First, on the north-east is the cliff of the glacier which caused the flood by damming back the lake and suddenly releasing it, and which extends almost to the edge of the falls. In

[1] All map numbers refer to the folding-map at the end of the *Journal*.

the middle are the cliffs of Hágafell, one of the flat-topped, steep-sided hills that are so common in this part of Iceland. It ascends in three steps towards the north, and runs back into the ice-cap for nearly 5 miles, finally passing under it at a height of 3000 feet. The south-west third of the shore consists of a sand-flat about 400 yards broad, beyond which is the degenerate snout of the West Hágafell glacier. (This name is due to Dr. Josef Keindl, who visited the area in 1929 (10) .)

The south-west shore consists entirely of recent lava from the Eldborgir, a small crater about 3 miles away, at the apex of a cone whose diameter is about 5 miles, and whose height above the surrounding plain is roughly 600 feet. The eastern shore is in two halves, the southern consisting of the cliffs of Fagradalsfjall, a range of hills about 2000 feet high, and the northern half of a long spit running westwards into the lake. The outlet gorge, in the north-east corner, is cut through the northern shoulder of Fagradalsfjall.

The western glacier on the north shore is not really a glacier in the usual sense of the word, as it is as broad as it is long, and may be better described as simply the ice-cap edge. It is along the edge of this that the other three lakes are ranged. To the north-east of Hagavatn there runs a valley about 3 miles long floored with moraine and bounded on the south-east by the foot-hills of the Jarlhettur mountains, and on the north-west by the ice-cap edge, which is here revetted by five hills, between which small glacier tongues have been formed. The north-east end is blocked by the southern slopes of the Jarlhettur, a range of mountains over 3000 feet high, running roughly north-east. The valley slopes up to these mountains, and the hills on either side of it reach heights of nearly 2500 feet at its upper end.

The south-western end of this valley forms the Fagridalur, the flood plain of the river Far, which drains Hagavatn, and it narrows in the south between the eastern spur of Fagradalsfjall and a small hill, Einifell, to a breadth of about a quarter of a mile. South-west of the former hills is another range in the same line, the Mosaskarðsfjall, and these appear to have held back the lava from Eldborgir to a certain extent, so that the ground to the east of these hills is approximately 400 feet below that to the west.

Topography of the Lake Floor

As already mentioned, a collapsible boat was taken for sounding the lake, and this work was carried out in some detail, as it could be done on wet days when the survey was impossible. Dr. Mill was kind enough to give us advice on the subject, and we followed more or less the methods which he used in the survey of the English lakes in 1895 (17). 300 feet of $\frac{1}{4}$-inch rope was taken, but only 200 feet was actually marked. This was done by tying strands of coloured string firmly to the rope in such a way that it could not slip. Red was used for every 20 feet, one strand for 20, two for 40, and so on up to each hundred. For the intermediate fives strands of yellow, green, and blue respectively were used. Two 7-lb. leads were taken, and one of these proved sufficiently heavy. The sounding was done by two people, one rowing for a fixed period, usually twenty strokes, and then backing water until the boat stopped, when the other sounded, and while he hauled in the line the oarsman booked the result. A straight line was kept by both men conning the boat on

Plate 1. The valley running from Fagradalsfjall to the Jarlhettur in 1929

Plate 2. The same valley in 1934

Plate 3. Hagavatn in 1925, seen from the east shore

Plate 4. The same view in 1934 (taken from Point 454 on Map 1)

to marks on the shores opposite to them. The oarsman tried to keep a steady stroke, and the number of soundings was divided into the length of each crossing, giving the distance between them. The rope was tested for stretch, but it was found to be negligible. We all did the two jobs in turn, but the organization and preparation of the equipment were due to Simpson.

The lake is clearly divided into halves by the two moraine spits, the large one running west from Fagradalsfjall and the small one east from Hágafell. South of these no sounding exceeded 30 feet. To the north of it the lake bottom shelves rapidly and a depth of 140 feet was found about 100 yards from the ice cliffs. Owing to the frequency of the calving it did not seem safe to go any closer. The following explanation of this division is due to White, and is probably the correct one. In geologically recent times the ice-edge must have lain where the two spits now are. Then occurred the lava eruption from Eldborgir, and possibly also from craters at the back of Hágafell which we observed, at about the same time that Skjalbreið, one of the most famous of Icelandic mountains, was formed. This lava flowed northward until it met the ice, which cooled it enough to stop further motion. The ice, melted by this and possibly also by the lava beneath it, retreated rapidly and left a large end-moraine which now forms these two spits, and probably also most of the deposit which is indicated in the western part of the lake by the smoothing out of the under-water contours there. The original shape of the lake, as excavated by the glacier, or simply as a hollow between Fagradalsfjall and Hágafell, was preserved in the north, but in the south it was filled up by the lava. Sections A, B, and C on Fig. 2 illustrate the argument. (See folding sheet.)

The Geology

Mr. White provided me with an account of his observations on the geology, but only in rough form, as he left for Kenya with Dr. Leakey almost as soon as he returned from Iceland. The geology of this area is fairly well known (9, 13, 20, 27, 28), and a general discussion of it would be outside the scope of this paper, which is only an account of the formation of the new fall at the exit of Hagavatn. I will therefore deal only with the geology as it affects the lake and the formation of the fall. I should like to say that the whole substance of this is due to White, though the form is not.

Almost the whole area consists of Tertiary volcanics, with the exception of the recent lava referred to above. These have been worn down to rounded forms in most cases, though the flat-topped hills already mentioned, of which Hágafell and Hloðufell are two near examples, are obviously exceptions. These Tertiary rocks consist of tuffs, conglomerates, and basalts, and have been much glaciated. At the fall itself the sequence is:

Brown tuff, well bedded.

The same, quite irregular.

A form of "Near pillow lava," composed of large rounded blocks about a yard in diameter embedded in soft tuff.

Irregularly bedded grey tuff, very soft and dipping down-stream at angles varying from 45 to 90 degrees.

When the flood came, it was extremely violent, and a huge mass of water must have poured over the rock face: particularly over the right bank of the

Leynifoss, where a small gorge was soon cut out in the rotten "near pillow lava." A second was made nearer the present fall, and as the upper rock was cut back, the stratified tuffs at the bottom would have been easily peeled off along their bedding planes. The water must have continued in this for some time, as in one of the large pot-holes of which this gorge is formed there are about a dozen boulders very well rounded which must have been sub-angular blocks in the moraine resting on the site of it. They are not formed of the soft tuffs and lavas in which the gorge is cut, and considerable energy or time must have been spent in rounding them, though of course they may have been almost this shape when left by the ice. Probably these three falls were occupied simultaneously, but were vacated in the above order, as the last is nearest to the lake, and lowest.

Two important photographs of the fall were available before last year, one, showing the gorge from the bottom, was taken by Herra Tryggvi Magnússon in 1929, and illustrates the article by Mr. Reynolds referred to above (24). The other, showing the actual fall from close to, was taken by Mr. Humble in 1930 and a copy was sent to the Society and is available in the Photograph Collection. From these it is apparent that little change has taken place since 1930 and it is probable that the whole formation of the gorge and the siting of the fall in its present position, took place in a few hours while the flood was at its height.

The rock, over which the fall now flows, shows glacial striation at water-level, proving that the drop in the level of the lake was due entirely to the removal of ice and moraine and not to any cutting down of the solid tuff or lava. Mr. Humble's suggestion that the rock channel was deepened is not, therefore, supported by facts (6). The present Leynifoss is not a single drop but falls in three steps which curve round to the right. Owing to this curve, the falls are hidden from view unless one stands actually on the left bank of the gorge, hence the name "Leynifoss" or "Hidden Fall."

The flood

The drop in the surface of the lake was about 20 feet and the volume of water so released a little less than 2,000 million cubic feet. Plate 3, showing the lake in 1925, was taken by Herra Magnússon on a visit to it in that year. It is not surprising that the bridge over the Tungufljót at Haukadalur, though 14 miles below, was swept away. It seems probable that this flood was greater than any of the previous recorded ones from four lines of reasoning. In the first place the farmers with whom we talked said that it was the greatest of the three that they remembered. This may be discounted for two reasons: that it was the most recent, and that it destroyed their harvest, which the others did not. Nevertheless it lends support to the argument. A second fact in favour of this theory is that the last flood was strong enough to cut the gorge, which the others were not, though they may have weakened the rock considerably. In the third place, there exists now only one high-level beach, presumably because all the others were eroded away as it rose this last time. There is little trace of anything in the way of a cut beach in this case, only a piling up of the loose scree, and this was carried up by the waves as the water rose. There is no trace of another above it.

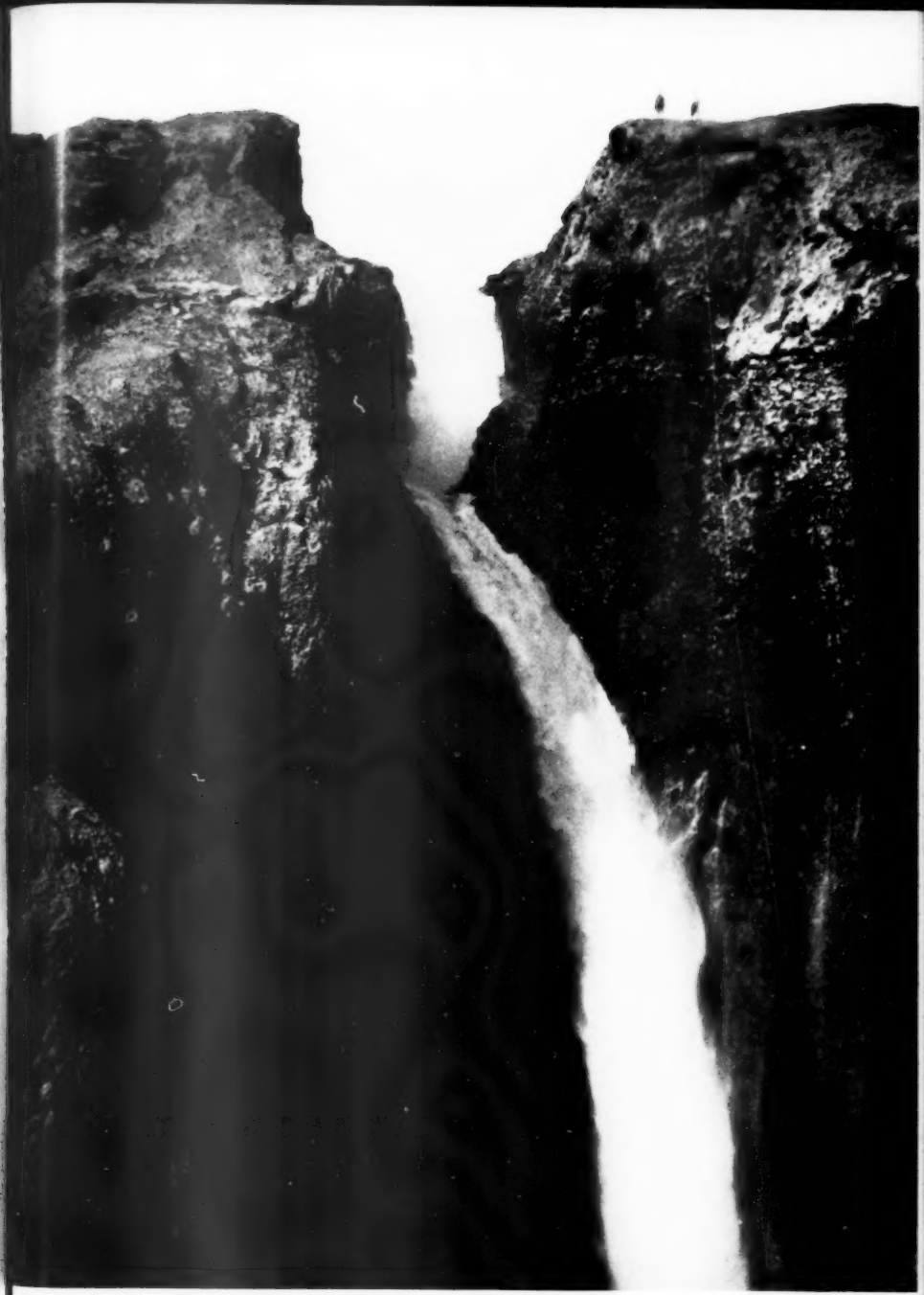


Plate 5. The Leynifoss

Plate 6. Þórisdalurvatn in 1918

Plate 7. Langvatn in 1918

The fourth line of argument is the retreat of the glaciers, which appears to have been greater in the last few years than it has for some time, at least in historical times (22). In connection with this it may be of interest to consider the economy of the lake, though the data are not very full. The flow of the outlet river was measured above and below the fall, in both cases with some accuracy, as the depth was measured for every 2^1_2 feet of breadth, and the surface velocity measured in five different parts of the stream. In the picture of the Leynifoss (Plate 5) there may be noticed on either side of the fall itself several small streams springing from the rock, and it appears that these, together perhaps with other hidden ones, carry about two-fifths of the outflow, a surprisingly large proportion. The actual figures were, for the section above the fall, 5·95 cu. m/sec., and for that below, 9·84. These were unfortunately not taken on the same day, but the flow of the springs is presumably the same under all conditions, unless the lake freezes thickly enough for the ice to cover their inlets (although of course temporary blockage may occur, and the effects of an increased head of water may be important). Assuming that this is so, we have for their daily flow roughly 350,000 cu. metres.

From the reports of the farmers it appears that the glacier, after the flood of 1902, did not again block the outlet till 1909, so that the water rose steadily for twenty years before the last flood. The area at low level is 10 square km., and at high level 11, and the difference in height is about 7 metres, so that the volume to be provided in those twenty years was about 70,000,000 cubic metres, representing a daily increment of 10,000 cubic metres.

From local accounts the only outlet of the lake, when the glacier was damming it, was by these springs. If these carried a volume comparable to what they do to-day, then we can only conclude that the rise of the lake was pure chance, for the daily increment was about 3 per cent. of both the outflow and the supply from the glaciers. It is surely unlikely that the latter should have remained within such narrow limits, and a variation of 20 or 30 per cent. from one year to another, or from one decade to the next, would have produced a very large variation in the level of the lake.

Although the proportion of the summer rate of melting to that of the whole year must be large, and therefore the average daily supply may have been comparable with the average increment, it is difficult to see why the springs should have a very much larger flow in summer than in winter, unless they freeze during the latter, and it is hardly cold enough for that; and if their yearly rate was comparable with their summer one, then that of the melting must have been too, or manifestly the lake would never have risen at all.

The most likely possibility seems to be that the springs were greatly enlarged by the action of the flood, and we know that it removed a large part of the hill-side through which they flowed, and that the glaciers are melting very much faster now than they did during the twenty years before the flood. It can hardly be said that their rate of supply at the moment over a year is comparable to what it was then, or the springs would have lowered the lake in the last five years and the fall would have dried up. This may be happening to a certain extent, as the farmers said that although the stream was much greater than it was before 1929, it is slowly decreasing. It may be thought that the effects of the flood are still perceptible, and that the outflow has not yet reduced the

lake to what we may call "normal" level. Although the data are approximate, it can be shown that if we neglect the flow in and regard the lake as a closed basin with a 7-metre-high dam in front of the outlet, and the dam is then opened, the lake will lower its level to within a few inches of the sill of the outlet in a week. Although the steady flow in and out superimposed on this evacuation flow may alter its rate of diminution slightly, it cannot have any great effect, and we may safely say that a month after the burst no abnormal flow in the river could be ascribed to the continuation of the flood.

It therefore seems probable that the volume of the springs and of the melt-water is very much greater than it was, but that the latter is not quite large enough to maintain the outflow of the last few years. All this is extremely speculative, and only a series of measurements of the flow over at least a year will settle these questions. Since that however is not likely to happen for some

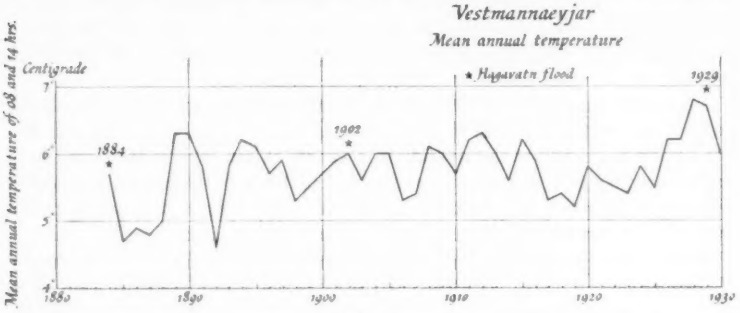


Fig. 1

time, it has perhaps been worth while considering them in detail from the data we have.

The ice retreat

In considering the retreat of the glaciers, we are upon more solid ground. The first point to be taken is the change of climate that has occurred. Plate 6 shows the Þórisdalurvatn, a lake to the north of the main system and separated from it by a ridge running into the ice. This lake lies at a height of 2225 feet above sea-level, and when we visited it was completely free from snow. Plate 7 shows the Langvatn as it was in 1918, with miniature glaciers on its banks, which are completely absent now, in fact there are large patches of grass. A comparison also of annual temperature means shows the same increase of warmth, though there are no stations nearer than 80 miles, so these must not be taken as applying to this area too closely (Fig. 1).

With regard to the actual retreat of the ice, Plates 1 and 2 were both taken from the northern shoulder of Fagradalsfjall, though not from the same spot, and they show the whole length of the valley up to the Jarlhettur, the former being taken by Herra Magnússon in 1929, and the latter last year. They show that in 1929 the ice edge was against the hills on the south-east side of the valley, whereas now it consists of a series of tongues which scarcely pass between the hills on the north-west side As an interesting corroboration of

this, we found a remnant of the glacier lying in the upper part of the valley, and separated from the parent mass by the slopes of the valley side. It was visible from near the Jarlhettur. There was also in one of the tributary valleys on the south-east side an interesting succession of beaches formed by a lake dammed back by the ice.

White noticed also a line of moraine, running across the valley of the river Far, appearing again on the northern slopes of Fagradalsfjall, on the east side of Hágafell, and parallel with the edge of the ice from Sandvatn to the northernmost unnamed lake of the series. It is brown, from 4 to 6 feet high, about 12 feet broad, and shows little sign of weathering or dissection by streams, so that it probably represents a very recent advance followed by a retreat, which must have begun some time before 1925, as the edge then was some way behind it (Map 1).

Turning to more recent times, it is evident that both the two lakes above Hagavatn have had recent drops in level, as they both now have exits through the ice, and show signs of recent higher levels on their banks. At Langvatn the course of events was particularly clear, for a well-marked beach 10 feet above the present level runs right round the lake, and two dry exits were found, one that had evidently been used for some time (Plate 10), and another nearer the ice and about 2 feet lower that cannot have been used for long, as the water has done little more than clear away the moraine. Map 3 is a plan and section of the lake, showing these exits and the present one through the ice, which is only used now by a trickle of water, except perhaps in spring. The release of the water when it found a way under the ice was evidently sudden. It occurred the year before last, apparently, as the farmers were unable to get past the western end of Hagavatn to collect their sheep, because there was a continuous sheet of water from it to Sandvatn. It is possible that the drop of Sandvatn occurred at the same time, though the evidence there is not so well marked, and may simply represent the temporary high level due to this flood. The channel cut by the flood of Langvatn in its own deposits is interesting, as it shows excellently the typical varve or banded clays deposited in glacial lakes, presumably due to the different rates of sedimentation in summer and winter (Plate 8). A rough measurement of these gives the lake an age of at least a hundred and fifty years, though of course this is very approximate, but it indicates that the ice edge had been fairly static until the year before last.

More recently still, in fact during the stay of the expedition, it was found that the cliff of the East Hágafell glacier, which had caused the dam, was still retreating fast. Cairns had been built on Hágafell and north of the fall to be in line with the ice-cliff edge during the first fortnight, and when a sight was taken along these in the last week it was found that the cliff had retreated considerably, a distance estimated to be nearly 50 yards. If we had known that such a great change was possible in so short a time, accurate measurements would have been taken, and it is greatly to be regretted that this was not done. An attempt was made to measure the forward movement of the two glaciers by aligning cairns on Hágafell on to dirt cones on their surfaces, a method which was estimated to give an error of less than a yard. No movement could be detected in four weeks, and this explains to a certain extent the phenomenal

retreat of the eastern glacier, as it was continually calving small icebergs, and the northern half of the lake was often full of them. They seldom crossed the line of the two spits as the water was too shallow. In accordance with the wishes of Herra Eyporssón of the Reykjavik Weather Bureau, who is making a study of the Icelandic glaciers (5), cairns were built at the edges of the glaciers where possible and the date of their erection and distance from the ice was written on a piece of paper and sealed in tins inside them.[1]

The ice channel

It is interesting to compare the evacuation of Hagavatn and Langvatn with those of glacial lakes in other parts of the world. A channel was cut at the edge of the glacier, estimated by Herra Óláfsson the surveyor to be 350 yards long by 30 broad (24). It is evident that the whole of this cannot have been filled with ice, for Mr. Seaver stated that he saw no ice on the way up the Far valley two days later, which would have been hardly possible if such a great volume was swept down by the flood (24). It is more probable that this channel was open for most of its length before the bursting of the final piece, and it would seem that that was at the upper end, from a study of the photographs, as the ice there looks more recently broken.

What is surprising is that the water should have cut such a channel, for although one might expect it, actually burst dams seldom show such a cut, but are usually characterized by a tunnel, the size of which often appears insignificant compared with that of the dam itself. We have an example recently in the flood of the Mendoza river in the Argentine, caused by the bursting of a dam formed by the Plomo glacier, of which an account appeared in the *Journal* last year (8). In that case the water cut a tunnel under the glacier in the usual way. The amount of water released seems to have been about the same, but otherwise there is little in common between the two cases. Another recent example is the Talsekwe river in British Columbia, where again the water found a sub-glacial route (11).

The two classic examples are the Shyok (14, 15) and the Marjelensee (4), but conditions are different, owing to the greater part played by the sun in melting in lower latitudes. In both these cases however the channel is cut beneath the ice, and turning to a better analogy, the Daemmevand, in Norway, on the edge of the Hardanger Jökull, the same phenomenon is apparent. This lake was visited by Munro in 1892 (18), and Mockler Ferryman in 1894 (7), and both record that the water drained beneath the glacier, sometimes spouting up through its lower crevasses.

In the case also of Langvatn, whose flood has been referred to already, the new channel lay under the ice for nearly half a mile. The reason for this anomaly of the outlet of Hagavatn must lie in the topography and the condition of the glacier, which, if it was degenerate in 1929, as was probably so, would have been very thin at the end of its snout. It would therefore have been easier for the water to have swept this away than to have burrowed beneath it. As regards the topography, the natural outlet lay parallel to the glacier edge rather than at right angles to it as is usually the case.

[1] See Appendix.

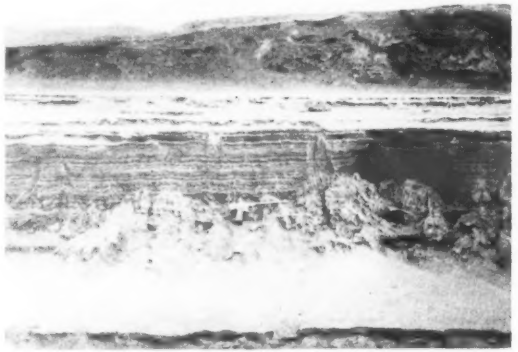


Plate 8. Varve clays in the Langvatn outlet

Plate 10. The Dry Falls of Langvatn

Plate 9. Tunnel in the ice from the lower end of Langvatn

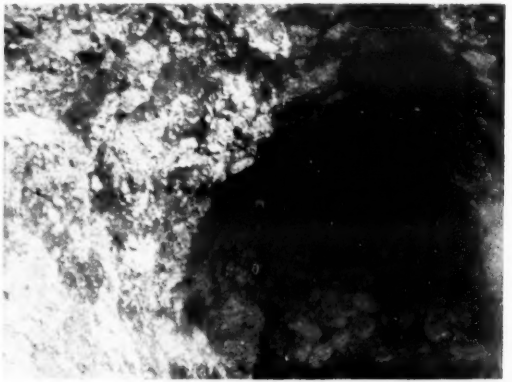


Plate 11. Rounded boulders in the Dry Fall

Plate 12. The outlet channel of Hagavatn in 1929, showing the southern Jarlhettur peak

Plate 13. View of the Leynifoss from Einifell

Movements of the glacier

There have been no measurements of the rate of flow of this glacier, except the ones we made, which had only a negative result, so that our information about its movement is rather vague. We have however the fact that last year the forward flow was less than a yard in four weeks in the height of the summer, which is generally taken to be the period of greatest movement. Therefore we can say that the movement is probably less than 12 yards per year. Beyond this point we can only estimate, but we have a certain amount of information which will help to make such an estimate reasonable.

We may assume that some portion of such a yearly movement will be consumed by the melting back of the ice-cliff during the summer, so that the total advance of the ice edge may not be more than a few yards in a year. If this rate of flow is correct, there is no doubt that the glacier is at present retreating, as the cliff was cut back very much more than twelve yards in the short time that we were there, and this cutting back occurs as long as the lake is ice-free.

Bearing in mind that the figure for the flow is a maximum, it is apparent that it will have to be increased considerably if the glacier is to advance, and there are reasonable grounds for supposing that even if it started to advance this year, it would take a considerable time to block up the channel again. As mentioned above, we know that after the 1902 flood it bridged the gap in seven years, but we do not know how far it went back on that occasion, although from a study of the temperature records it seems that the melt during that time was probably not as large as it has been during the last five years, and we are justified in assuming that the retreat was not so great. Five years had elapsed since the last flood when we saw the glacier last year, and it was obvious that unless something remarkable happened, it would be a good many years before the glacier again blocked the outlet. It was 300 yards from the bank, and still retreating.

It is clear that if the rate of movement remains constant at 12 yards per year, it will take at least twenty-five years for the glacier to cover that 300 yards. On the other hand, if the glacier is to fluctuate, it must be because either the melt or the rate of flow alters, and in other cases it seems to be usually the latter which is the deciding factor. In a paper to this Society last November (16) Professor Mason brought forward the theory that topography may play a decisive part in the movement of a glacier, and that its rate of movement during an advance may be out of all proportion to its rate during retreat. That may be so for Himalayan glaciers, but the conditions there are different in at least three particulars.

In the first place, there is no question here of sudden additions to the glacier by avalanches, for there is nowhere where they can come from, as the source of the glacier is a smooth ice-cap, unbroken by any peaks. Secondly, there is temperature. The antarctic glaciers, considering their great size, seem to have very slow rates, which Wright (32) puts down to the lower temperatures; and Chamberlin has reported the same thing from North-west Greenland (2). In the Himalayas there is a considerable difference between winter and summer temperature, which is lacking in arctic lands, and in a small island like Iceland. One would expect such extremes to make for sudden movements, to say nothing of the large amount of water acting as a lubricant, as suggested by

Mr. Pilditch in the discussion on Professor Mason's paper (16). That however is pure conjecture, and I do not propose to carry it any farther.

There is still another point of difference, namely of slope, and I think it is rather a fundamental one. Professor Mason did not give the slopes of the glaciers he was talking about, but he mentioned that the Yengutz Har glacier retreated 3000 yards between 1906 and 1930, and also that it went back 2000 feet vertically. This gives a slope of 1 : 4·5, and Dr. Helbling, in his paper on the Plomo glacier, gave that a slope of from 1 : 7·9 to 1 : 5·5 (8). In a paper to the *Alpine Journal* in 1932 (15) Professor Mason gave slopes of 350, 500, and 400 feet per mile for the Chong Kumdan, Kichik Kumdan, and Aktash glaciers respectively, or 1 : 15, 1 : 10, 1 : 13. The Hagavatn glacier drops 450 metres in 8 km., giving a slope of 1 : 18, which is very much less than those cited, except for the Chong Kumdan, and that glacier seems to be fairly immune from such sudden advances, as it has a period of approximately fifty years (15). As far as slope is concerned therefore there seem to be reasonable grounds for supposing this glacier immune from any sudden advance.

In connection with this it may be of interest to note that at least one of the Icelandic glaciers is liable to violent movements, for Herra Stefánsson told me that the western of the two galciers flowing into Hvítárvatn was noticed to have advanced several hundred metres in a month or so. Hvítárvatn is a large lake to the north-east of Hagavatn, and is much visited, but so far as I know no proper investigation of the glaciers has been made, and I could not discover the source of this information. From photographs and such maps as there are, it appears that the slope of this glacier is fairly large. Its rate has been measured over a short period, and found to be 6 inches on a summer day (26).

Conclusion

In spite of the scanty information about this glacier, particularly with regard to its past history, I feel that it is possible to give some idea when another flood may be expected. Taking into consideration the following main factors:

(1) that the present retreat of the glaciers is the greatest that has occurred in at least the last fifty years, and that they appear to be still retreating;

(2) that the periods between the last two were eighteen and twenty-seven years respectively;

(3) that the present flow of the glacier is less than 12 yards per year, and that it is probably immune from sudden advances;

I think that it is justifiable to say that the outlet will not be blocked for another ten years. If we add to that a further twenty years for the lake to rise to the level of 1929 (as elapsed before it), we compute that a flood of comparable size will not occur within the next thirty years, though a smaller one may take place sooner. It is not possible to fix an upper limit, because it may be that the present retreat of the glacier is not an oscillation, but a stage in the gradual diminution of the ice-cap, in which case there will never be another flood at all. The lake is often visited, both by tourists and farmers, so that we should get reports of the position of the glacier from time to time, which will be of great interest and value.

APPENDIX: MARKING CAIRNS

The following cairns were built to mark the edge of the glacier. X_1 and X_2, 200 and 316 metres respectively from the ice edge. Error ±10 metres. Location: about 400 metres east of "Upper" Sandvatn, both on high rock domes. Date established: August 14.

Y_1 and Y_2, 190 and 256 metres from the ice edge. Error ±2 metres. Location: about a kilometre west of the upper end of Hagavatn, on the flat water sorted moraine. Established on August 14.

Z_1 and Z_2, 100 and 200 metres from the ice edge. Error ±2 metres. Location about 300 metres west of the western side of Hágafell, on the sand in front of the glacier. Established on July 31.

A small cairn was built on the north bank of the fall about 100 metres from it, and it was, on August 3, in line with the top front Hágafell cairn (point 630), and the edge of the eastern glacier This cairn is unlikely to be visible from that on Hágafell, so no record was left in the latter. In addition to these, several survey cairns were left, but they are of no great importance, so no list is given.

Inside the cairns the following form of record was left: This cairn was metres from the ice on 1934. Please measure the distance of the glacier from here, and send the result, with this paper to Jón Eyþorsson, Verðurstofan (Weather Bureau), Reykjavik, and rebuild the cairn. (*Signed*) J. W. Wright. *Cambridge Iceland Expedition* 1934.

These were written in Indian ink on drawing-paper, and sealed up inside Huntley and Palmer biscuit tins.

The locations were in many cases not very good, but they had to be near the glacier, as we had no theodolites, and could not have measured a long distance accurately enough. It is hoped that the cairns will be found by interested visitors, who will make a note of the position of the ice edge, and leave a further record. I do not think the farmers will disturb them.

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DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: The paper is on "The Hagavatn Gorge," which gorge has at various times given place to lakes, hanging lakes, as it were. We know of the "hanging" gardens in Babylon and "hanging" glaciers in the Himalayas. Now we are to hear of "hanging" lakes which, I understand, in case of considerable thaw are subject to a sudden rise in level and flood the surrounding country. Mr. Wright, who will read the paper, is a student at Cambridge working, I understand, for a Tripos in Geomorphology. He will explain the geological and meteorological

aspects of the gorge and the lakes which form therein. I will not keep you, but ask him to read his paper.

Mr. Wright then read the paper printed above, and a discussion followed.

The PRESIDENT: We welcome here this afternoon Dr. Nielsen, Secretary to the Royal Danish Geographical Society. We should be very pleased if he would make some observations.

Dr. NIELS NIELSEN: The series of undergraduate expeditions from Cambridge, especially to the Arctic regions, has been paid much attention to in Denmark. We have observed with great satisfaction how the results of these young men's work has produced new knowledge of the matters that claim our great interest. Perhaps the most valuable result of the whole series of undergraduate expeditions is that one obtains knowledge as to who among the younger men are the most able to carry out such work. It has been to me very interesting to hear this afternoon the lecture by one of those undergraduates and to see the results he has brought home.

It seems to me that it is of the utmost value to obtain the best possible information as to the geomorphological features of the Icelandic glaciers, the reason being that one of the most difficult questions in Icelandic geology and geography is what we call Palagonite-formation. It seems to me that this Palagonite-formation, a whole series of at least 1000 metres, arises partly from volcanic forces, partly from glacial forces, and then there occur very curious catastrophic features, one of which is the occurrence of great autumn floods. You have heard this afternoon of a type of such floods, but that is only one of those features. Volcanic eruptions take place under the ice and deliver enormous quantities of water. Other floods arise from warm sources which melt and produce subglacial lakes that are emptying to the ice-edge. Explanation of how the Icelandic development during the Ice Age took place is impossible unless we know something of what is happening now. We have been glad this afternoon to have a new contribution to the geomorphology of Iceland, and I hope Mr. Wright will continue his studies in that connection.

The PRESIDENT: Mr. Lewis is a member of the Staff of the Cambridge School of Geography. Perhaps he will add a word or two.

Mr. W. V. LEWIS: We have listened to a most interesting paper by Mr. Wright. He obviously went to Iceland with a group of problems clearly in mind, he studied them closely and has produced most commendable results. My own admiration for Mr. Wright is increased because I realize, as the President has already reminded us, that he has prepared this paper with the bogey of examinations ahead of him. We all know how at this time of year examinations have an unfortunate habit of monopolizing one's time, but that has clearly made no difference to the quality of the paper Mr. Wright has produced.

I think it was Dr. Longstaff who likened Iceland to a scientific laboratory; actually, he likened one small strip of it to a whole series of laboratories. Mr. Wright seems to have demonstrated the truth of that statement in another part of Iceland. The country cannot of course compare with Greenland or the Antarctic either in magnitude or in low temperatures, but it does seem to have its peculiar contribution to make to glacial geomorphology—to mention a side different from that to which Dr. Nielsen has already referred. In this respect it seems to possess advantages over the more truly Arctic regions. For instance, it seems to be increasingly evident that glacial sculpture is most effective in relatively high temperatures: that is, when freeze-and-thaw can take place actively. Certainly Iceland seems able to provide this rapid freeze-and-thaw. Also it is important to realize that the final stamp of a glacial period is that left

on the topography by the retreating ice-tongues and glaciers. Here again we have in Iceland splendid examples of retreating ice-tongues, and no doubt many of the conditions Mr. Wright depicted on the slides must have been simulated at an earlier period in this country.

Turning to some of the points which Mr. Wright so interestingly developed, one which appealed to me very much was the technique he employed in measuring the flow of the streams. I have not heard of other expeditions in the Arctic regions which have measured the flow of streams issuing from glaciers, but it seems to me something that might open up fertile sources of enquiry. Mr. Wright clearly demonstrated one instance of the value of such observations in his estimate of the amount of water which seeped through a volcanic barrier.

There are one or two questions I should like to ask him in that connection. He gave the measurements of the flow of the streams over the fall as about 5·95 cu. m/sec., and below the fall, 9·84. I wonder if he could give us an idea of the probable error of those measurements. I know of course that one cannot give a precise probable error, but, say, $5{\cdot}9 \pm 1$ or $\frac{1}{2}$, or some such figure. From the nature of the problem these river measurements are only approximate, but I am sure Mr. Wright could give us some indication of the order of accuracy, so that we should know what reliance we can place on his figures.

He said that he measured the flow of water above the falls and below them on different days. At Vatna Jökull we were very impressed by the difference in the flow of the streams from one day to another, and still more so from one week to another. A period of mild weather, and especially of rain, would swell the streams enormously and cold weather would limit them. I wonder if Mr Wright recorded such great differences, and if so, what effects they might have on his results.

His figures further yield many interesting points which I cannot help feeling would lead to useful results if this type of research were proceeded with. For instance—I think my figures are correct—I calculated that his lake would have filled up from its present level to flood level in about four and a half months, if the outflow he recorded had continued. Yet it actually took twenty years to fill. That shows in a remarkable way the enormous melting which takes place in August compared with the average for the year and is very similar to the observations we made round Vatna Jökull.

A further point: Mr. Wright suggested that the springs probably flow more or less constantly throughout the year. This implies that they do not freeze in winter. That again rather interested me because we gathered that the melt-water flowing from Vatna Jökull ceases in winter.

May I conclude by thanking Mr. Wright very much indeed for the most interesting series of observations he has brought before us this afternoon?

The PRESIDENT: Mr. Simpson was the surveyor to the expedition—an undergraduate of Trinity. Would you add a few words, Mr. Simpson?

Mr. H. J. SIMPSON: I am afraid I am not in the least qualified to deal with the points raised by Mr. Lewis. I also find it difficult to add anything to what Mr. Wright has said, because he has dealt with everything so very fully. I would however like to say something about the weather with regard to our programme.

We had, on the whole, bad weather, though warmer than usual. There was a lot of rain and a lot of wind. This hindered our survey a good deal. We tried to do our sounding operations on the wet days, but they were usually accompanied by a good deal of wind and sudden squalls which made the lake quite unsafe for a small boat.

Mr. Wright has dealt with all the soundings very fully.

We fed mostly on pemmican, biscuits, sugar, butter, and chocolate. We were warned that since we were going to be in a fixed camp all the time we should have one or two luxuries, so we took jam and oats, and found this diet most satisfactory.

That is all I can say. Everything else has been dealt with very fully indeed.

The PRESIDENT: Professor Debenham is the Director of the Scottish Polar Institute at Cambridge. We should be pleased to have his comment.

Professor F. DEBENHAM: I am rather at a disadvantage because the last three speakers all know the country personally and have sat on those ice-caps, or very near them, whereas I have not been near the country. The fact that we have been hearing about ice-caps has its humorous side because during this term Mr. Wright has to come to listen to me on that subject. To-day I am pleased to end the term by reversing the position: he has told me something about them.

Not knowing the country I do not wish to speak of the technical points, but leave time for Mr. Wright to reply to the questions that have been raised. I should however like to commend him, as other speakers have, on the way in which he has carried out this particularly neat piece of work, his way of delivering it to us, his excellent illustrations and his maps, all representing the work of four weeks which, as we have heard, has been hindered by a great deal of bad weather, and by quite a number of other difficulties.

If we go a little farther back, as I can, and realize that the foundation on which those maps was laid was surveying with a plane-table on Sheep's Green or some equally uninteresting place at Cambridge, and realize too that much of Mr. Wright's preparations were made at odd times when sitting for his examinations, I think you will join with me in congratulating him still further.

I said I should like to reverse the position and sit at Mr. Wright's feet rather than he at mine. On the other hand, I shall have the privilege of examining him in about a fortnight, whereas he cannot examine me.

The only point arising out of the paper that I would like to mention is one which came to me through talking to Dr. Nielsen recently. He was present at the obsequies of a very much vaster flood, because it was occasioned by volcanic activity in the larger ice-cap of Vatna Jökull. He described to those who were listening to him that the flood was so great that the edge of the vast ice-cap was practically floating. People walked on it and felt it moving on the flood which was about to come out at the bottom. I commend that picture to Mr. Wright because I do not quite agree with what he said with regard to what probably happened at the time of the Hagavatn flood—that there was not enough ice shown in the flood débris to prove that the blockage had been complete. I am inclined to think, after listening to Dr. Nielsen, that what happens just at the time of the flood may be catastrophic to a degree. The whole edge of the ice, perhaps for as much as 700 yards, will be floating at the last moment before the break takes place. But I must not take up more of your time with technical matters.

Mr. WRIGHT: I should like to reply to Mr. Lewis' questions, so far as I can. With regard to the accuracy of the measurements I think that they should be of a fairly high order, because we chose a good section of the river, about 100 feet long, with comparatively smooth bottom, and we made, as I said, measurements for depth at every 2½ feet of the breadth which is about 70 feet, so I think the accuracy of the observations is reasonably high. I have not worked out what sort of order it would be because the daily variation was very great, but in this connection it does seem that the proportion of the flow of the springs to the total flow is approximately the same, or rather that the flow of the springs is fairly constant, because although I only recorded two lots of measurements, one above

and one below, we actually took several more. As the first lot were taken by Mr. Simpson, who has not had the pleasure of profiting by Mr. Lewis' instruction in measuring river-flow, he took the mean of the surface flows in different parts, and we did not think that was accurate enough, but from the consideration of his measurements it does seem that the figures I gave are approximately right. I cannot go nearer than that.

With regard to seasonable variation, again I cannot say; but it does seem to me that since those springs come out so low down their sources are probably fairly low down, because the channel just above the exit of the lake is comparatively deep. Therefore if there is freezing on the surface of the lake it probably will not extend as far down as that. But all that is problematical.

I should like to add that the whole subject was treated rather hypothetically because we only had that data and there did not seem much chance of getting more. Apart from that I have nothing more to say, except to thank you very much indeed for the extremely kind way in which you have listened to me.

The PRESIDENT: I think we must all appreciate the fact that Iceland is a very convenient and fruitful region, handy for us, to which young men with a scientific bent can go and do useful work in the short period of a vacation. As Dr. Nielsen has explained, the Danish scientists and Government give those young men every facility and cordial welcome, realizing that they can do helpful and useful work in conducting such researches as these and in recording their scientific observations. I think you will all join with me in congratulating Mr. Wright on having been able to accomplish what he did: work which was evidently of considerable value. We hope he may have further opportunities of pursuing his enterprising activities in that region.

You will, I know, show your appreciation of his paper in the usual way.

THE BRITISH TRANS-GREENLAND EXPEDITION: *Continuation from the May Journal of a paper read at the Evening Meeting of the Society on 21 January 1935, by*

MARTIN LINDSAY

APPENDIX I: SURVEY

LIEUT. A. S. T. GODFREY, R.E.

The survey of the Expedition extended along the western limits of the mountains of the east coast of Greenland from lat. 70° N. southwards to Mount Forel (lat. 66° 53′ N.). The map has been drawn by the Royal Geographical Society after the astronomical observations had been computed by the Ordnance Survey.

Our intention was to work down the mountains, mapping on a series of astronomical bases. The survey was carried out under difficult conditions; the weather was very bad throughout, so there were two breaks. We fixed ten astronomical positions during the survey and in between these we made compass traverses with the sledgemeter giving distances between sub-stations. In all there were forty such stations and sub-stations. At each astronomical station we took a morning azimuth and L.M.T. observations and midday latitude, and balanced the morning observations with the afternoon ones. It was not possible to balance the latitudes.

It would have been interesting had we tried some form of photogrammetry using a small and portable photo-theodolite. Some form of principal point traverse akin to the Arundel method in aerial survey might be possible, and if successful would be ideal for exploratory survey. Not only would work in the field be reduced to a minimum but a very much fuller and contoured map could be produced. From any one station we could not take rays to more than about a dozen points, as we had to keep them in mind in order to recognize them from the next station. It was astonishing how their character altered as we travelled past them. We could not take a plane-table, and in consequence have brought back only a number of spot heights. Additional detail was plotted from horizontal photographs by the ordinary method of knowing the focal length of the camera lenses.

The instruments taken were:

- 3¼-inch Watts theodolite, with short wooden legs.
- Battery of three aneroid barometers.
- Hypsometer.
- Two thermometers.
- Aeroplane compass.
- Prismatic compass.
- Three half-chronometer watches.
- Stop watch.
- Long-wave wireless time-signal set.
- Tables, drawing instruments, computation forms, observation books, charts, etc.

In addition to our survey instruments we kept on another sledge a sextant and mercury artificial horizon with tables and charts. This was an emergency set in case we lost the survey sledge down a crevasse. It was a weighty set and for another journey I consider a bubble sextant as used by the Royal Air Force

would do instead of the sextant and artificial horizon. If a sledge were lost the party would be in difficulties, where every ounce of weight would count. A bubble sextant would be adequate for navigation.

The instruments were carried in a specially designed three-ply box lined throughout with sorbo rubber sheeting. The sorbo lining was a novelty in polar practice and was a great success; it should be copied by all subsequent expeditions. Not only did it protect the instruments from shock but it kept out drifting snow and even water when we were sledging through morasses of thaw water at the edge of the Ice-cap.

All the instruments worked excellently except the aeroplane compass. This was fixed on a sledge to assist navigation in bad weather, and it was a great help until it failed us after two or three days. For another journey of a similar nature I would have all the chronometer watches waterproof; only one of ours was, but as the time-signal set did not fail chronometers were not needed. I would also have one prismatic compass for each man of the party. In reducing ourselves to one for the party we were carrying weight-saving too far. The wireless set was designed by the late Captain Lemon, of the Royal Corps of Signals, from experience gained with the B.A.A.R.E., and was very simple to operate.

The actual degree of accuracy of our survey stations can best be shown by quoting figures from our astronomical observations.

The average difference of latitudes by circum-meridian altitudes taken on consecutive days in the same position was 5·7 seconds of arc, which corresponds to about 200 yards on the ground.

Our morning and afternoon L.M.T. observations differed from nil (our best) at Station 13 to twelve seconds of time (the worst) at Station 26. The mean discrepancy was under five seconds, which, at our average latitude, would correspond to about half a mile on the ground.

The average discrepancy between morning and afternoon azimuths was less than a minute of arc. As the 3¼-inch Watts theodolite has no striding level no observations for azimuths with it, under however favourable conditions, can be guaranteed to be more accurate than this.

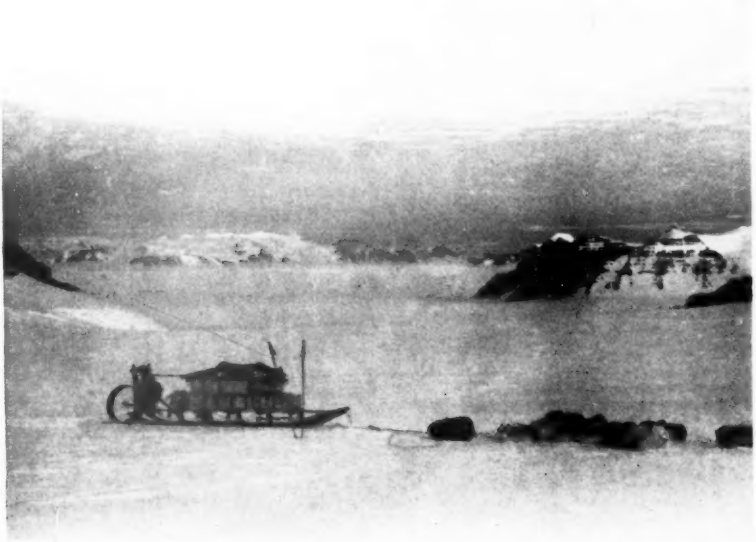
The computations for the altitude of the highest peak in the Watkins Mountains are given in full:

Point 23 *from Station* 5

Log Distance 275,000′ =	5·439	3327
	2·372	0000
Log K	3·067	3327
∴ K = 1167·7 seconds of arc		
K =	00° 19′ 27·7″	
Elevation =	+00 32 28	
S =	+00 51 55·7	
Log tan S =	8·179	1635
Log Distance =	5·439	3327
Log *h*	3·618	4962
∴ *h* =	4154·3 feet	
Ht. of Stn. 5 =	9029 feet, mean of	9015 feet, 9043 ,,

∴ Ht. of Pt. 23 = 13,183 feet

Basalt outcrop with radiation pool. (Look across the Grenlands Styrelses Glacier from S.W. of Station VII)



The Watkins mountains beyond Christian IV Glacier, from a point 2 miles E. of Station XII

A crevasse north of Station XXVI

11,500 10,850' 10,170' Mt. Forel 11,500

The Forel Panorama. (From Station XL)

Point 23 from Station 7

Log Distance 306,000′ = 5·485 7214
2·372 0000

Log K 3·113 7214
∴ K = 1299·3
K = 00° 21′ 39·3″
Elevation = +00 30 52

S = +00 52 31·3
Log tan S = 8·184 0984
Log Distance = 5·485 7214

Log *h* 3·669 8198
∴ *h* = 4675·4 feet
Ht. of Stn. 7 = 8357 feet, mean of {8356 feet / 8358 „}

∴ Ht. of Pt. 23 = 13,032 feet

Height of Pt. 23 from Station 5 = 13,183 feet
„ „ „ „ 7 = 13,032 „
∴ Mean Calculated Height = 13,100 „

It must not be forgotten that in surveys of this nature the accuracy of the instruments used is not necessarily a guide to the ultimate accuracy of the survey. Whether one has a $3\frac{1}{4}$-inch Baby Watts or the latest Zeiss theodolite makes little odds except in so far as one may be easier to adjust and use than the other. The difference between accurate and inaccurate survey is made by considerations such as the amount of pemmican one had the night before, or how cold one's fingers are, or the fitness of the party.

In this connection we found that finger gloves would have been an inestimable boon. There is a great prejudice against finger gloves among those who have been in the polar regions, but chamois leather gloves over hands that have been well warmed and with the circulation going strongly keep one's fingers warm for a surprising time; for colder conditions an under-pair of airman's silk gloves will give more insulation. A pair of airman's gloves, a pair of chamois gloves, and a pair of mittens extending well up the wrist over the lot would enable accurate work to be done at −40° F.

APPENDIX II: ALTITUDES

An accurate determination of our altitudes was considered to be of great importance for three reasons: Firstly in order that the principal contours of the Ice-Cap could be completed as the result of our journey; secondly because the heights of intersection points in the Survey are relative to the altitudes of the astronomical bases; and thirdly to estimate the height of the high centre north of Mount Forel.

The altitudes of our camps were computed first by Lieut. E. H. Thompson, R.E., of the Geographical Section, General Staff, by the traverse method of carrying heights across the Ice-Cap from sea-level to sea-level, the closing error being then distributed. This was regarded as being no more than a preliminary investigation while Dr. Brooks, of the Meteorological Office, was computing

the altitude by the more satisfactory method of comparison with simultaneous aneroid readings at sea-level stations. However, although Lieut. Thompson's results are less accurate than those of Dr. Brooks, they are of considerable interest in comparison with them, in view of the fact that the traverse method was used to compute the height of the Antarctic plateau.

Dr. Brooks reports that "the probable error of any one height is of the order of 100 feet," which is an error of approximately 1 per cent. He also states that the calculated altitudes should be regarded as minimum figures, in view of the fact that both the Ice-Cap and the coastal regions are generally covered by an inversion layer of temperature, so that the mean of the simultaneous measurements on the Ice-Cap and at sea-level corrected for daily variation will be colder than the mean temperature of the free atmosphere needed for barometric height measurements. Dr. Loewe states that the forthcoming publication of the Scientific Results of the Wegener Expedition "shows quite clearly" that the true mean temperature would give altitudes approximately 1½ per cent. higher than our figures, amounting to 150 feet at the highest camps.

Turning to consider the height of the ice north of Mount Forel (11,500 feet) which appears to be not only the highest part of the Greenland Ice-Cap but also the highest-known ice-plateau in the world, it will be seen that the calculated altitude of our highest camp, on August 23, was 10,858 feet. As the probable error of any one camp may be 100 feet, the true height would seem to lie between 10,758 feet and 10,958 feet. And with the augmentation of 1½ per cent. it would then appear to be between 10,920 feet and 11,120 feet.

The mean height of the expedition during the journey, between June 18 and September 4, was 8640 feet.

I am deeply grateful to Dr. Brooks for the many hours of work he spent in reducing our aneroid heights, and also to Lieut. E. H. Thompson and Dr. Loewe.

M. L.

CALCULATION OF ALTITUDES FROM ANEROID READINGS

Dr. C. E. P. Brooks

Instruments.—Three aneroid and three altimeters were carried, but of these one aneroid and two altimeters became useless before the Ice-Cap was reached. The remaining two aneroids are Negretti and Zambra's 3-inch aneroid No. 12774 and a "Watkin" aneroid lent by the Royal Geographical Society. The third altimeter was Mk. VA No. 10872/W, hired from the No. 1 Stores Depot, Royal Air Force, Kidbrooke.

The information available about these instruments is as follows:

Aneroid No. 12774.—According to Negretti and Zambra, the error when issued was "of the order of ±0·05 inch."

When returned, this aneroid was "looked over but not subjected to a full test," and the errors were probably still about ±0·05 inch.

At the start of the expedition a comparison with a mercury barometer gave a correction of +0·100 inch at 29·555 inches.

At the close of the expedition a similar comparison gave an error of +0·024 inch at 30·016 inches.

Watkin Aneroid.—This was tested by Negretti and Zambra in April 1934 and was accurate to ±0·05 inch from 30 to 18 inches. The comparison at the start of the expedition gave an error of −0·095 inch. The comparison at the close of the expedition gave an error of −0·056 inch.

The two aneroids kept fairly well together throughout, and it is assumed that their mean gives a reasonably accurate value for the pressure.

Altimeter No. 10872/W.—This was tested before and after issue, and the errors were practically unchanged. In addition a detailed comparison was carried out on 21 February 1935 between the altimeter readings in feet up to 15,000 and a mercury barometer. Unfortunately, when the altimeter readings on the Ice-Cap were converted to inches by means of this comparison, they were found to be about an inch below the aneroid readings. The readings of the altimeter were therefore not used in the height calculations.

Temperature.—The temperature of the air on the Ice-Cap was obtained by means of a sling thermometer, which gives sufficiently accurate determinations in these conditions. Since temperature on the Ice-Cap undergoes a large diurnal variation, which extends only to a shallow layer of air and does not affect conditions in the great mass of free air on either side of the plateau, all temperatures were corrected for diurnal variation, using a table given by De Quervain.[1]

Base-Level Values.—For the purposes of the reduction, values of pressure and temperature at mean sea-level were required for the successive points reached by the expedition. The values of pressure at M.S.L. for the observation hours of 1 hour, 7 hours, 13 hours, and 21 hours, were computed by the Forecast Division of the Meteorological Office from their working charts; values for intermediate hours were interpolated directly. The route of the expedition lay entirely within a triangle formed by Godhavn, Scoresby Sound, and Angmagssalik, and the temperatures at sea-level were interpolated from readings at these three stations, corrected for diurnal variation by means of hourly observations at Godthaab.[2]

Method of Reduction.—The reduction was made arithmetically, using the formula:

$$\text{Height (feet)} = (\log p_0 - \log p)\,(123T + 56320)$$

where p_0 is pressure at M.S.L. and p pressure at station-level, both in inches. T is the air temperature (mean of station and sea-level) in Fahrenheit degrees. It was assumed that, at the low temperatures prevailing, the effect of humidity can be neglected.

In general two observations were made at each camp, one on arrival and one before departure. In each of these cases two heights were computed independently; there were fifty-five such pairs and the average difference, irrespective of sign, was found to be 99 feet. Apart from any systematic errors due to instruments or the hypotheses of reduction therefore, the probable error of any one height is of the order of 100 feet.

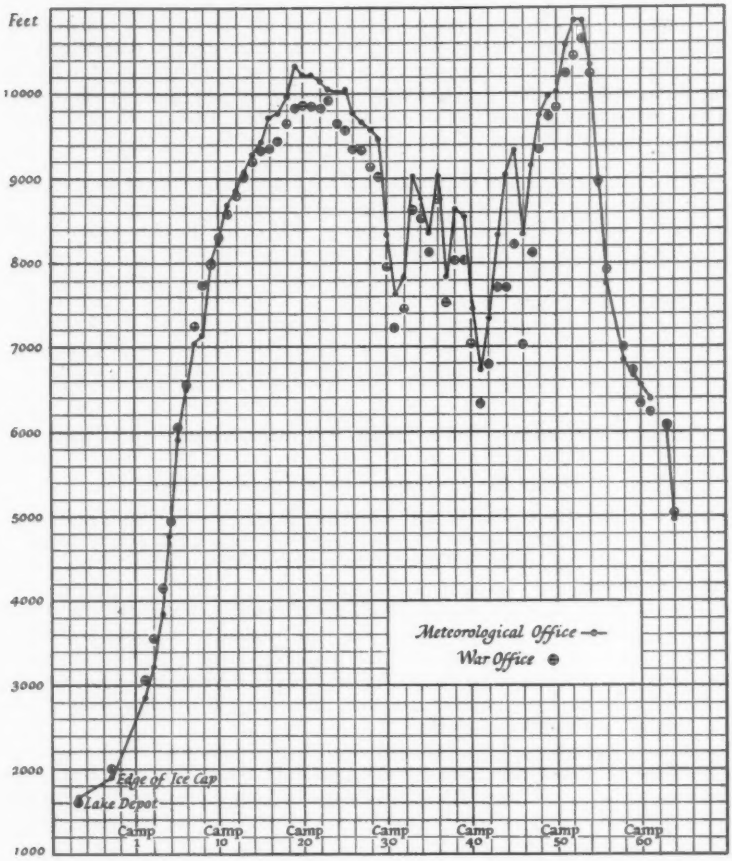
Calculated Heights.—The calculated heights are shown graphically, together with those calculated independently by Lieut. E. H. Thompson, R.E., by transit from one station to the next. It will be seen that at the higher levels of the plateau the heights calculated by direct reduction are several hundred feet above those given by the transit.

The main reason for this systematic difference lies in the existence over the Ice-Cap of a thin layer of abnormally cold air, several degrees colder than the free air at the same level on either side of the plateau. The air pressure on the Ice-Cap is however determined very largely by the general run of the isobars at

[1] De Quervain, A., und P. L. Mercanton, 'Ergebnisse der Schweizerischen Grönlandexpedition, 1912–13,' Zurich, Denkschr. Schweiz, Natf. Geo. Bd., 73, 1920.

[2] Copenhagen, Institut Meteorologique de Danemark. 'Exploration Internationale des Regions Arctiques, 1882–83'; 'Expedition Danoise, Observations faites a Godthaab, Tome II, Copenhague, 1889.'

the same level in the free air, slightly increased by the layer of cold heavy air over the Ice-Cap. The transit method adopted by Lieut. Thompson assumes that the hypothetical column of air between station-level and sea-level consists entirely of this cold air of the Ice-Cap, and since in cold air the vertical decrease of pressure is more rapid than in warmer air, the heights calculated by this method are relatively low. This effect is magnified by the fact that many of the observations were made in the early morning, when the air temperature on the



plateau is especially low. The method adopted in the direct reductions avoids these sources of error to some extent by giving as much weight to the temperature over the sea coasts as to that over the Ice-Cap, and by correcting the latter for the average diurnal variation of temperature. Consequently the average temperature of the air column is several degrees higher than in the transit method, and the calculated elevations are also higher. Even by this method the assumed temperatures of the air column are still probably somewhat below the mean temperature of the free air over the coasts and seas on either side of the Ice-Cap,

and the calculated heights are therefore to be regarded as conservative or minimum figures.

Minor irregularities in the differences between the two calculations may be due to changes in the pressure at sea-level during the day's march, which were allowed for in the direct reductions but not in the transit.

ALTITUDES BY THE TRAVERSE METHOD

Lieut. E. H. THOMPSON, R.E. (Geographical Section, General Staff)

The traverse method assumes that during a day's journey the barometric change was entirely due to change in height and that any alteration due to weather took place during periods of rest. This assumption was supported by the fact that except in the last fortnight the party did not travel in unduly bad weather, when barometric changes would be greatest. The method entailed carrying heights across the Ice-Cap from sea-level on the west coast to sea-level on the east coast. The closing error on the east coast was 123 feet, which, if divided among the fifty-five stations, gives no appreciable error in the difference in height between any two stations. The heights of all the stations were then corrected to conform with the closing error and accepted as the best results by this method. The mean error of all the stations is probably not more than 200 feet.

The results of only two aneroids were used in this determination. These two agreed extraordinarily well throughout the journey, the greatest difference between their readings being 0·16 inch on August 2. The aneroids were compared with mercury barometers before and after the journey, and their readings corrected in the usual way for a barometric traverse.

APPENDIX III: GEOLOGY

DR. GILBERT WILSON

During recent years East Greenland has been the scene of widespread geological investigations. So far however the work has of necessity been limited to the coastal sections and the immediate hinterland, supplemented by reconnaissance aerial surveys. This is particularly true of the region between Scoresby Sound and Angmagssalik. Geological maps of this coastal stretch have been published by Lauge Koch, *M.O.G.*, vol. lxxiii, 1929, and more recently by L. R. Wager (*ibid.*, vol. cii, No. 2, 1934); the latter's work connects with that of the former at Cape Dalton and continues southerly to Angmagssalik. The mountainous coastal ranges between Scoresby Sound and Kongerdlugssuaq were flown over and photographed by Lauge Koch and by Knud Rasmussen in 1933.

From these main sources of information it appeared that the area lying between lats. 70° N. and 68° N. forming a mountainous tract of country, was dominantly composed of Tertiary basalts, locally pierced by plutonic intrusions. The geology of the western and north-western flanks of this mountainous area was unknown, and it was hoped that perhaps the British Trans-Greenland Expedition might have been able to establish the western margin of this great basaltic field. This unfortunately was impossible, as from lat. 70° N. to Kongerdlugssuaq, both observations and photographs show that the basalt flows continue to, and beneath, the Ice-cap. North of lat. 70° N., where land was first sighted after crossing the continent, the mountains, at a distance of about 30 miles, appeared jagged and serrated. They differed markedly from the basaltic piles which

showed characteristic step structure (Plate 4) (see also L. R. Wager, *op. cit.*, Plate 6, Fig. 1). It seems therefore probable that these more jagged peaks behind Scoresby Sound were carved out of rocks of the Metamorphic Complex appearing from below, or faulted up from below, the basalts. A possible alternative reason for the appearance of these peaks is that they may be composed of basalt that has been slightly metamorphosed; such rock has been shown by Wager to weather as a massive rock and not in "step form" (*op. cit.*, Plate 6, Fig. 2, and p. 31).

The western limit of the basaltic field was observed in an isolated nunatak, NNW. and 45 miles from the head of Kongerdlugssuaq, at 69° 17′ N., 33° 14′ W. This exposure, Plate 20, shows strongly developed columnar jointing, which was not observed in the other basalts that formed the larger mountains. South of this nunatak, as far as Mount Forel, the rocks observed were apparently entirely members of the Metamorphic Complex. It seems therefore that the south-west margin of the basalts swings northwards and north-westwards in the previously unexplored country west and north of Kongerdlugssuaq fjord.

Throughout the whole length of the basaltic ranges mapped by Lindsay and his party, he reports that the flows lay horizontal. Wager, on the other hand, finds that along the coast these Tertiary lavas have a general seaward or south-easterly dip which varies from 2° to 12°. Interpolating between these two series of observations it would appear that the mountains between the sea and the route followed by the Expedition were carved out of the south-eastern limb of a large flat anticline, which trends approximately parallel to the coast. The north-westerly dipping limb of such a structure would naturally be hidden below the central ice-sheet. Recent movements affecting the level of the peneplain may possibly reflect the earlier structures, as Wager has shown to occur at Kap Tupinier (*op. cit.*, p. 29); but speculation on this subject prior to obtaining detailed elevations within the mountain mass is unwise.

Specimens of the basalts were collected from the following localities:

Lat. 69° 35′ N.	long. 30° 13′ W.	Station 6.
69 42	29 44	Station 7.
69 17	33 15	Nunatak Camp.

These specimens are preserved in the Petrological collection, Imperial College of Science and Technology, London, S.W.7, Numbers 7490–7494. The majority are typical microporphyritic olivine bearing tholeiitic types. One specimen however, No. 7491, from Camp 35, is an aügitite. None show any markedly alkaline affinities such as might have reasonably been expected considering the nature of many of the scattered coastal plutonic centres.

APPENDIX IV: METEOROLOGY

MARTIN LINDSAY

The meteorological observations of the Expedition cover a period of eighty days, from 18 June to 5 September 1934. They could not be taken at fixed times owing to the elastic hours that had to be kept while sledging. Two observations were taken each day, on striking and pitching camp, and the time of each observation was noted. On days that the party did not travel observations were taken at 0900 hours and 1500 hours (L.M.T.), these being the times for astronomical observations.

As there is the remote possibility of an air-route over the Ice-cap these observations are discussed in the order of their importance from this point of view instead of in the usual sequence. Thus visibility is followed by cloudiness, wind, precipitation, temperature, and pressure.

PAGE(S) MISSING

(i) *Visibility*

The scheme of observations given in the *Meteorological Observer's Handbook* could not be adopted, as during the crossing there were no objects to observe and distances to landmarks during the survey period were not known. In the Arctic during the summer visibility is excellent unless obscured by either fog or diffused light, or falling or drifting snow. In August 1931 C. Dan (about 2000 feet high) was seen 220 miles away from a height of 10,000 feet. As there is very seldom an entire lack of wind, fog is usually in patches and varying continually, and visibility of about a quarter of a mile is perhaps average during fog. When vision is obscured by diffused light, or falling or drifting snow in any quantity, visibility is very much less and hardly ever exceeds 100 yards. Accordingly visibility was observed as nearly as possible to correspond with the three standard objects C (110 yards), E (550 yards), and G ($1\frac{1}{4}$ miles). Thus poor visibility caused by snow was recorded as C, although it was usually considerably less than 110 yards. E refers to conditions of fog with a varying visibility averaging something like half a mile. G signifies very good visibility, at least 1 mile, and usually perfect.

Owing to the frequent occurrence of fog at night but not in the day time, and as we often travelled at night, visibility was when possible noted at midnight in addition to the two daily observations. In the latter part of August and in September no midnight observations were made owing to the decreased intensity of illumination.

Table I: Percentage Frequency of Different Grades of Visibility

	June				*July*				*August*				*September*				*Total*
Obs.	12	13	11	36	31	21	31	83	31	31	13	75	5	5	0	10	204
	AM	PM	Mn	All	AM	PM	Mn	All	AM	PM	Mn	All	AM	PM	Mn	All	
C %	8	0	10	4	33	33	33	33	22	17	32	23	20	0	—	10	24
E %	0	0	18	7	7	6	24	13	25	19	15	20	40	40	—	40	16
G %	92	100	72	89	60	61	43	54	53	64	53	57	40	60	—	50	60

Visibility was C for 24 hours on 1 day out of 12 in June, 12 out of 31 in July, 4 out of 31 in August, and 1 out of 5 in September: total 18 out of 80 days.

A comparison with Wegener's Eismitte observation during this period, when they are published, will be of value. The outstanding point of Table I is the large percentage of bad visibility due to bad weather, *e.g.* 12 days in July with a visibility of 110 yards or less (see (iv) Precipitation). This makes a closer examination of the data desirable.

Table II: Weather Associated with Impaired Visibility

(All observations)

		June	*July*	*August*	*September*
Vis. E (550 yds.) or lower	%	11	46	43	50
Associated with drift-snow ..	%	3	18	15	—
precipitation ..	%	2	20	20	40
fog	%	6	8	6	—
Unaccounted for	%	—	—	2	10

Table II makes it clear that the main cause of poor visibility was precipitation. Drift-snow sufficiently high to obscure visibility was always present with winds of Force 7 and might or might not be concurrent with falling snow. Frequently during periods of the most intense drift the zenith was observed to be clear. The occasional obscurity referred to as fog was due to water in the atmosphere,

either as ice particles or super-cooled drops. During foggy nights when the temperature was between 0° F. and −20° F. ice-crystals frequently formed on the surface, to detract greatly from the glide of the sledges. Rime was observed on several occasions when fog was associated with low temperatures.

(ii) *Cloud*

Table III: Mean Cloudiness in Tenths of Sky Covered

	June	*July*	*August*	*September*	*Journey*
A.M. ..	2·6	5·3	5·8	8·6	5·6
P.M. ..	3	5·9	5·2	8·4	5·6
Mean ..	2·8	5·6	5·5	8·5	5·6

The mean value 5·6 may be compared with the normal of 6·4 for Angmagssalik,

or 3·4 for the B.A.A.R.E. Ice-cap Station, September 1930–February 1931, or 5·8, the mean value of Wegener's Eismitte Station, August 1930–July 1931.

(iii) *Wind*

The wind force was estimated on the Beaufort Scale. In the absence of the usual criteria (smoke, leaves, etc.) for the use of the Beaufort Scale on land, reliance was placed mainly on judging the pressure of the air; in this case anemometer observations taken in 1930 had trained the observer to associate the Beaufort numbers with the usual velocity equivalents, and it was thus possible to make reasonably accurate estimations.

As the sledging party in the course of the journey passed continually from the region of one prevailing wind to that of another, no useful purpose will be gained by tabulating percentage frequencies of wind direction. The prevailing wind experienced is shown on the sketch-map.

This sketch shows that the winds experienced in the latter half of the crossing confirm the theory of Wegener's Expedition that the highest point of the Ice-cap on the latitude of Eismitte was slightly beyond their station. The direction of the winds during the survey period is in accordance with what would be expected with a high centre north of Mount Forel.

Panorama from Station II

Grønlands Styrelses Glacier. (*Panorama from Station IX*)

The Watkins Mountains (right centre) beyond Gronau Nunatakker. (Panorama from Station V)

Crown Prince Frederiks Mountains. (Panorama from Station XXVII)

Crown Prince Frederiks Mountains. (Panorama from Station XXVII)

Table IV: Percentage Frequencies of Specified Ranges of Beaufort Numbers

		Percentages				*Days of*	
	Obs.	0–1	2–3	4–5	6–7	Force 6	Force 7
June	25	38	39	15	8	1	1
July	62	25	34	29	12	4	2[1]
August	62	30	46	19	5	1	1[1]
September ..	10	80	20	0	0	0	0

[1] Consecutive days.

It should be noted that only mean levels of winds were noted, no account being taken of gusts; thus in the "moderate gale" of July 30–August 2 the wind several times in gusts rose to Force 8 and 9.

It is of interest that in July, at the highest part of the crossing, winds of Force 4 and Force 6 were observed, and there was no period of calm at that time. This is noteworthy in view of the old hypothesis that there would be no winds at the centre of the Ice-cap; a theory that caused Wegener to instruct his meteorologists not to take an anemometer to Eismitte, as they would have no use for it. Actually, only one or two days of calm were observed at Eismitte in twelve months.

(iv) *Precipitation*

Table V: Numbers of Days of Precipitation

	June	*July*	*August*	*September*	*Total*
Snow	1	13	8	2	24
Rime	1	3	1	0	5
Ice crystals	2	4	2	0	8
Rain	0	2[1]	0	0	2
Total	4	20	11	2	37

Total number of days examined 80.

[1] As rain fell during two days of snow already enumerated, this figure is not included in the total for the month.

The outstanding point in this tabulation is the number of days (*e.g.* thirteen in July) during which snow fell, a very high percentage for midsummer on the Ice-cap, but which corresponds with observations taken at Eismitte during the summer of 1931.

(v) *Air Temperatures*

Table VI gives the mean and extreme shade temperatures experienced during the journey.

Table VI: Mean and Extreme Temperatures, in Degrees Fahrenheit

	June	*July*	*August*	*September*
Mean A.M. ..	8	17	16	28
Mean P.M. ..	18	27	20	41
Mean day	13	22	18	35
Obs. max. ..	29	40	50	40
Obs. min.	−12[1]	−5	−3[2]	23

[1] Observed before midnight.

[2] Observed at 0900 hours.

On both these nights the temperature at the coldest period fell to about −20° F.

The mean temperatures are not of much value as they represent the averages of temperatures taken in the morning and evening and not near midday or midnight, when the highest and lowest temperatures would have been recorded.

It was not possible to carry a maximum or minimum thermometer owing to the fact that the mercury in these instruments gets misplaced with the jolting of sledging. Extreme temperatures were recorded in occasional readings taken when the weather appeared to be exceptionally hot or cold. As it is unlikely that the thermometer was ever read at the precise moments of extreme temperature, both the maximum and minimum readings can safely be regarded as under-estimations. Temperatures were read to the nearest 0·5° F. and are tabulated to the nearest degree.

The observations show that the inter-diurnal variation of temperatures is large and depends to a great extent upon the direction and strength of the wind, *e.g.* the average temperature for August 11 with a west wind, Force 1, was 6° F., which increased the following day to 25·5° F., when the wind veered to south-east, Force 4.

That a temperature of 33° F. was recorded on July 10, at a height of 10,160 feet, is of great interest, as the highest temperature recorded at Eismitte, at a height of 9950 feet, in the summer of 1931 was 26° F., and as the German scientists there examined the stratification of twenty years' precipitation and found no evidence of thawing.

(vi) *Atmospheric pressure* (note by Dr. C. E. P. Brooks)

As the heights of the camps varied from day to day the observed pressure readings have no direct meteorological interest, but have been employed to determine the approximate heights of the camps as described in Appendix II.

The general meteorological situation, as shown in the charts of the northern hemisphere published in the British Daily Weather Reports, has however considerable bearing on the remaining meteorological observations. From June 10–13 and 18–21 conditions were mainly anticyclonic and quiet, with a short interval of more variable pressure distribution from June 14 to 17. On June 23 a barometric depression over Labrador moved north-eastwards and from that date until August 2 most of Greenland came under the influence of a series of disturbances of moderate intensity centred over the coasts or the neighbouring seas. There were a few short intervals of more anticyclonic conditions, notably on July 14–15 and 27–29. From August 3 to 26 Greenland was under the influence of an anticyclone or of a ridge of high pressure connecting two anticyclones except for periods of disturbed or variable weather from August 7 to 10 and 13 to 21. A deep depression lay over Iceland from August 27 to 31 and conditions were again disturbed during the early days of September. The disturbed conditions during July were reflected in the relatively great frequency of fresh or strong winds and of precipitation during that month.

APPENDIX V: TRANSPORT

MARTIN LINDSAY

The journey was mainly a problem in organization with a special reference to transport. The type of equipment for a sledging party is established, and it is known that a well-found team can travel in the polar regions for as long as they can be supplied with food and fuel and can maintain their equipment and motive power without replacement. But how far and how fast they can travel and the length of time they can exist without replenishment or reorganization depends upon the efficiency of their transport.

Our particular problem was to maintain three men in the field for ninety days, with a safety margin for unforeseen eventualities. The arrangements made had

to allow of great mobility so that the party could travel more than 1000 miles, and on occasions cover long distances quickly to allow the maximum time for the survey period. The risk of the arrangements breaking down had to be reduced to a minimum.

On a sledging journey the transport problem is threefold: carriage, motive power, weather. A sledge is required which is capable of carrying the belongings of the party; dogs are necessary to pull the sledge; conditions of weather and surface must be suitable.

An unsupported sledging-party of three men intending to stay out for ninety days will start with their three sledges loaded each with at least 1000 lb. To stand up to this weight the sledge must be of the finest material and workmanship. Ours were of the Nansen design made at Byfleet of ash and hickory by E. L. Pitman, an aircraft carpenter, and they were a great improvement upon those turned out by mass-production methods in Norway. In places they were specially strengthened to a new design, a cross-section of which has been lodged at the Polar Research Institute. The weight of each sledge was 60 lb.

Unless the surface is fairly hard and smooth it is not possible to start off such heavily loaded sledges from a standstill. Even then the dogs need to be trained to take the pull all together at the word of command, and the men must be of strong physique to be able to ease the lie of the sledge by jerking the front of it from side to side.

Motive power is a more complex problem, for it involves the whole delicate art of dog-driving, which comes beyond the scope of these notes. There is no difficulty in driving trained teams 300 or 400 miles over the Ice-cap in a journey lasting three or four weeks. But after that, when the dogs have lost interest and their only desire is for fresh surroundings and more food, then it is that the experienced dog-driver comes into his own. The second and subsequent teams will always follow the leading sledge; the difficulty, and it is a very real difficulty, is to get the front team to pull ahead. This can be overcome for a time if there is a spare man to ski in front but, after this device has lost its novelty, if the party does not include one expert to drive the leading team, the dogs will have their own way and transport arrangements collapse. We started the Ice-cap crossing (from a point 3870 feet above sea-level and about 12 miles from the edge of the Ice-cap) with thirty-seven dogs of which twelve were taken through to the end of the journey. The number was gradually reduced as the loads became lighter, the dogs in the worst condition being killed and fed to the others. It is necessary to kill dogs on such a journey as a large number is needed at the start when the sledges are heavy, and it is not possible to carry food for so many all the way. The surviving dogs benefit enormously by a periodical return to fresh meat, and could not be maintained in good condition for anything like so long if fed only on pemmican. If the dogs are fed till the moment that they are killed and are then shot with a humane-killer they experience no suffering, and indeed come to a more merciful end than if they had been left with the Greenlanders.

For the monotony of an Ice-cap journey West Greenland dogs are probably the best in the world. They are not so intelligent as Canadian and Labrador dogs, and therefore do not require so many interests to keep up their spirits. Jakobshavn and Cape York have much the best dogs, as only in those two places is dog food abundant. The Jakobshavn dogs are trained to severe cold, since very low temperatures are experienced each winter at the halibut-fishing camps, and Jakobshavn is the best place to learn dog-driving.

To summarize the two important transport lessons learnt by this expedition: Firstly, the real difficulty of dog-driving starts only after about 500 miles have

been covered and at least one expert dog-driver is needed from then onwards; secondly, it would not be possible to start sledges weighing more than about 750 lb. except when the sledging surface is quite exceptionally good.

APPENDIX VI: RATIONS

MARTIN LINDSAY

The scale of daily rations drawn up for the British Trans-Greenland Expedition, as compared with that of the British Arctic Air-Route Expedition, was as follows:

	B.A.A.R.E.	*B.T.G.E.*
	oz.	*oz.*
Bovril Pemmican	8	7
Maypole Margarine	8	4
Plasmon Biscuits	5[1]	2
Plasmon Oats	3	3
Plasmon Powder (phosphates of milk)	2	3
Cadbury's Cocoa	1	2
Cadbury's Chocolate	3	3
Tate and Lyle's Sugar	4	4
Harvest's Peaflour	2	2
Horlick's Malted Milk	½	—
	36½ oz. per diem	30 oz. per diem

[1] The biscuit ration of the B.A.A.R.E. was thought to have been 4 ozs. per diem. The makers state that this ration was actually 5 ozs.

Each expedition took daily 1 small teaspoonful of concentrated lemon juice, and the B.A.A.R.E. also 1 dessert-spoonful of cod-liver oil and a small portion of dried yeast powder and salts.

The scale of 30 oz. per day was cut down proportionately by one-seventh as the ration-box intended for seven days was made to last eight days, to enable the party to stay out longer. This reduced the ration to 26 oz. per day. Parties of the B.A.A.R.E. had managed on less than this, particularly on journeys towards the end of the expedition (when stomachs were accustomed to accommodate themselves to a small bulk, and when the familiarity of sledging rations made no appeal to the appetite), but we, at a time when the temperature was between zero and −20° F. at night, found ourselves ravenously hungry on 26 oz. a day. After a week the ration was increased by about 4 oz. per man per day of dog Pemmican, which is derived entirely from fresh beef with 28 per cent. fat and 65 per cent. protein, and has a total calorific value of 509 calories per 100 gms., while man Pemmican has 42 per cent. fat and 45 per cent. protein, and a total calorific value of 565 calories per 100 gms. The relative values for human consumption is, in the opinion of Messrs. Bovril, in proportion to the calorific values of the fat contents, which are 248 and 385 respectively.

When it was decided that the B.A.A.R.E. ration of 36½ oz. would have to be reduced to 30 oz., the margarine was cut down most, as fairly warm conditions were expected. Our temperatures were usually well above zero though −20° F. was experienced at two stages of the journey. 4 oz. of margarine proved quite sufficient except for one member of the expedition, who has an exceptionally bad circulation. 2 oz. of biscuit was quite adequate; this is the lowest biscuit

content in any polar ration to date; Watkins's 5 oz. per day was a reduction of 7 oz. from pre-war British polar expeditions. The Plasmon Powder was increased on the advice of Dr. Zilva, of the Lister Institute of Preventive Medicine, to whom I am indebted for much help. 2 oz. of cocoa proved rather more than we could digest. The spoonful of cod-liver oil added to the B.A.A.R.E. ration to increase the Vitamin D content was omitted by us and also the yeast powder and salts and no ill effects were felt.

Were this journey to be done again I should increase the ration to 32 oz. and would not reduce this except in an emergency towards the end of the journey. I would take a ration as follows: Pemmican, 10 oz.; Margarine, 4* oz.; Biscuits, 2* oz.; Oats, 3½ oz.; Plasmon Powder, 2½ oz.; Cocoa, 1 oz.; Chocolate, 3* oz.; Sugar, 4* oz.; Peaflour, 2* oz.; Total, 32 oz. Also lemon-juice and a little tea. The quantities unchanged from our ration of 1934 are marked *. Dr. Zilva states that this ration contains a little over 4500 calories and more than 100 grms. of protein of high biological value; he would be in favour of adding to it 1 oz. of dried vegetables, ascorbic acid tablets and dried yeast. The dogs received 1 lb. per diem of Bovril dog pemmican, with fresh meat about once a week.

APPENDIX VII: PHOTOGRAPHY

ANDREW CROFT

The main items in our equipment were:

1 Kodak ¼ Plate Recomar camera, Compur shutter, f4·5, and 40 Super-sensitive panchromatic and verichrome film packs.

1 Kodak $3\frac{1}{4}'' \times 2\frac{1}{4}''$ folding camera, Compur shutter, Goerz lens f4·5.

1 Kodak $3\frac{1}{4}'' \times 2\frac{1}{4}''$ No. 1 folding camera, f6·3, and 80 Super-sensitive panchromatic roll films.

I arrived in Greenland early in October, my headquarters being about lat. 70° N. Although there was snow on the ground and the weather happened to be good, the reflected light was extremely deceptive; in such circumstances, for instance, it was a mistake to use a smaller aperture than f8 for a $\frac{1}{25}$ sec. exposure, with a K1½ filter and panchromatic films. Instantaneous photography is not recommended from the middle of November until the end of January: certainly not with cameras whose lenses are similar to the above.

The winter photography was mainly experimental, so adequate supplies of developing and printing equipment were taken for such a purpose. Everything came from Messrs. Kodak, except the Agfa flash-powder; of this one had to use more than double the specified amount, as the walls and surroundings of a Greenlander's house are dark and lacking in contrast.

All the cameras were taken at the start of the summer sledge journey, but, in order to save weight, the ¼ plate and film packs were sent back from the edge of the Ice-cap. The chief disadvantage this entailed was that after this there was no focussing-screen camera for close-up photography; however, as was discovered on returning home, the strong summer light had often penetrated into the sixty or so negatives exposed during the 130-mile journey from Jakobshavn. This had only occasionally been experienced with film packs under winter or spring conditions; roll films, on the other hand, gave no trouble of this sort throughout the whole year.

A Leica camera, taken in addition to the two folding cameras, got wet during the first week on the Ice-cap when the sledge concerned overturned in a swamp; the water damaged the shutter and the camera was useless.

The best Kodak was always used with a K1½ filter inserted inside the front Goerz lens. The inexpensive one, although originally taken as a stand-by camera, which of course took the same sized roll films, was used for the most part with a G filter; it has produced some surprisingly good cloud effects. Furthermore the G filter, as well as making the sky dark and the white clouds stand out, cut out haze and made the survey panoramas much clearer. Exterior attachable filters might have given better and more varied results, but they easily get lost or dirty and complicate proceedings for fingers already sufficiently cold.

A few photographs of blizzards were obtained by carefully shielding the camera with windproof material. In perfect cloudless weather and about noon-time during the month of June, the shortest successful exposure for a distant panorama, with a f32 aperture and a K1½ filter, was found to be 1/10 of a second. A Justophol exposure-meter was often used for photographs of a more experimental nature; it was however necessary to allow for particularly cold weather making the film emulsion work more slowly.

From the experience gained on this expedition I would always, when weight must be considered, recommend small folding cameras for Arctic photography. They should preferably be of the reflex type, to be used with super-sensitive panchromatic roll films and a selection of appropriate filters. With such equipment and a thorough knowledge beforehand of the cameras, most amateurs could obtain reasonably good results without undue difficulty.

APPENDIX VIII: DISTANCE LOG

From a point 12 miles from the edge of the Ice-cap. All heights are evening heights.

	Daily Distance	*Height*	*Total*	
	miles	feet	miles	
June 18–19	21·5	3,865	21·5	
19–20	25·1	4,749	46·6	
20–21	24·1	5,950	70·7	
21–22	23·6	6,509	94·3	
22–23	21	7,056	115·3	
23	Observation	—	—	
24–25	21	7,643	136·3	
25–26	18·8	8,047	155·1	
26–27	20·6	8,265	175·7	
27–28	18·1	8,701	193·8	
28–29	18·3	8,853	212·1	
29	Observation	—	—	
30–July 1	13·3	9,083	225·4	−20° F. at night.
July 1–2	16·2	9,262	241·6	
2–3	7·4	9,439	249	Half-day's travel.
3–4	14·4	9,731	263·4	
4	Changed to day travelling	9,773	—	
5	18·4	9,983	281·8	
6	20·4	10,325	302·2	
7	18·7	10,241	320·9	
8	16·2	10,225	337·1	
9	Observation	—	—	
10	6·8	10,162	343·9	Half-day.

		Daily Distance	*Height*	*Total*	
		miles	feet	miles	
July	11	15·5	10,065	359·4	Loads on two sledges.
	12	Blizzard	—	—	
	13	11·2	10,002	370·6	
	14	Blizzard	—	—	
	15	Blizzard	—	—	
	16	7	10,068	377·6	Half-day.
	16–17	14·9	9,785	392·5	Returned to night travelling.
	17–18	16·7	9,693	409·2	
	18–19	18·1	9,593	427·3	
	19–20	19·2	9,455	446·5	Lat. observation.
	20–21	25·7	8,326	472·2	
		End of crossing 469·5+12=481·5 miles from Halibut Camp.			
		Average 14·2 miles per day.			
		Average march 19·2 miles.			
	21–22	12	7,665	484·2	
	23	Observation	—	—	
	23–24	21	7,832	505·2	
	24–25	12·7	9,029	517·9	Observation.
	26	Observation	—	—	
	27	Observation	—	—	
	28	Blizzard	—	—	
	28–29	4	—	521·9	Half-day.
	29–30	16	8,769	537·9	Blizzard.
	30–31	Blizzard	8,357	—	
Aug.	1	Blizzard	—	—	
	2	Observation	—	—	
	2–3	18·5	—	556·4	
	3–4	23·5	9,091	579·6	
	4–5	14·6	7,843	594·5	
	5–6	21	8,615	615·5	
	6–7	27·2	8,590	642·7	Observation.
	8	Observation	7,467	—	
	8–9	18·2	7,467	660·9	
	9–10	22	6,783	682·9	
	10–11	21·8	7,387	704·7	Observation.
	11	—	8,335	—	Observation.
	12	13	9,045	717·7	Observation and changed to day travelling.
	13	16	9,325	733·7	
	14	11·1	8,367	744·8	
	15	Observation	—	—	
	16	8·4	9,173	753·2	Half-day, observation.
	17	12·8	9,711	766	
	18	Observation	—	—	
	19	22·5	9,992	788·5	
	20	Observation	—	—	
	21	18	10,039	806·5	
	22	11·8	10,597	818·3	Half-day, observation.
	23	4·9	10,858	823·2	
	24	3	10,854	826·2	
	25	10·9	10,343	837·1	Observation.
	26	23·5	8,919	860·6	
	27	26·1	7,783	886·7	−20° F. at night.
	28	19·5	?	906·2	
	29	21·1	6,860	927·3	
	30	6	6,702	933·3	Half-day, observation.
	31	16·7	6,586	950	

	Daily Distance	*Height*	*Total*	
	miles	feet	miles	
Sept. 1	7	6,399	957	Half-day.
2	12·5	?	969·5	
3	13	6,077	982·5	Observation.
4	22	4,958	1004·5	
5	25	Sea-level	1029·5	

Daily average during the journey .. .. .. 13·6 miles
Average march .. .. 19·3 ,,
Average height .. .. 8,460 feet

1029·5 miles is the distance covered from 12 miles east of Halibut Camp. 100 miles were first sledged with relaying to reach Halibut Camp, and 50–100 miles between Halibut Camp and the starting point, therefore the total length of the sledging journey was not less than 1030+150=1180 miles, of which the Expedition was self-supporting for 1080 miles.

APPENDIX IX

Note on Place Names

The three new names proposed by the Expedition—"Prince of Wales Mountains," "Crown Prince Frederiks Mountains," and "Grønlands Styrelses Glacier"—have been approved by the Danish Government.

THE CAMBRIDGE EXPEDITION TO THE ZAMBEZI VALLEY, SOUTHERN RHODESIA, IN 1934

JOHN KEIGWIN

DURING the summer vacation of 1934 an expedition from Cambridge University visited that portion of the Zambezi Valley which lies in the Lomagundi district of Southern Rhodesia, to make a survey of the Kariba Gorge and to carry out as much anthropological and geographical work as was possible in the limited time. The expedition was made possible by a grant and the loan of instruments from the Royal Geographical Society, and by grants from the Worts Fund of Cambridge and St. John's College. We are also greatly indebted to Professor Debenham and Mr. H. B. Maufe, Director of the Southern Rhodesian Geological Survey, for much valuable advice and encouragement. I should also like to acknowledge the help given me in the compilation of this paper by Mr. Sharland, who provided most of the material on the Kariba Gorge.

The expedition, consisting of Mr. John Keigwin, Anthropologist and Geographer, and Mr. C. P. A. Sharland, Surveyor, left England by R.M.S. *Winchester Castle* on June 8, arriving at Cape Town on June 28, and immediately left by train for Salisbury. Here as short a time as possible was spent in obtaining provisions and equipment before leaving by car for Miami on June 30, where native carriers were hired with the assistance of the Native Department. These provided the only means of transport possible in the Tsetse fly areas of the Zambezi Valley. Only fourteen carriers and two

personal servants were taken, since equipment and supplies had been reduced to a minimum in order to save expense.

The six-day journey to the Kariba Gorge was at first through hilly wooded country, later dropping some 3000 feet to the flat country of the Naodza and Zambezi valleys typified by huge baobab trees and thick scrub. A base camp was made at the junction of the Sanyati and Zambezi rivers as being the most suitable position for the surveyor, despite its distance from villages. It was also necessary, owing to the impossibility of trekking down the lower part of the Gorge, to find out whether it was possible to journey through the gorge by canoe. To reach the village at the gorge exit, 17 miles away, it was necessary to make a detour of nearly 45 miles. This was done by the Anthropologist who, after some delays, obtained a canoe and an experienced native there. He then made a journey up the gorge to within 4 miles of the entrance before the rapids made further progress impossible. Mr. Keigwin then travelled down the Zambezi to a large village beyond the Kafue confluence where his main work lay. Here the surveyor was to meet him early in September and, by taking another route following the line of the escarpment, to provide further knowledge of the area. Owing to a misunderstanding and a shortage of provisions the meeting did not take place till a fortnight later. On account of this separation the work progressed along different lines and thus can be naturally divided into the survey of the Kariba Gorge and the Anthropo-Geographical work of the lower country.

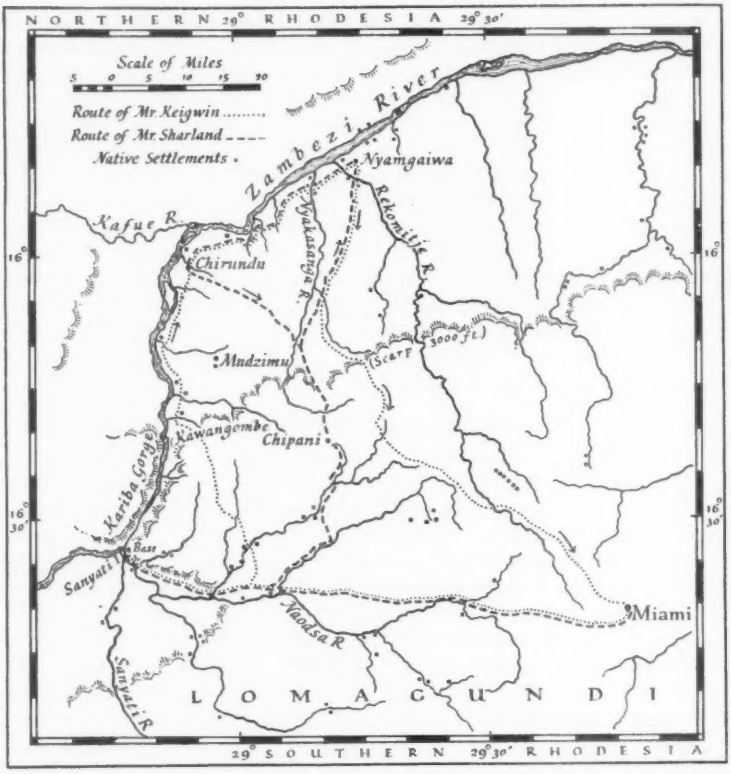
Notes on the Method employed in making the Plane-Table Sketch and Traverse of the Kariba Gorge

A few days were spent in reconnoitring for a base site. This was difficult owing to the thick vegetation and the only one suitable was found to be on a reach of the Naodza river, which at that time of year was dry. A base of 850 yards was measured with a 100-foot steel tape. From these stations the four hills were fixed by intersection, all four being situated on the right bank of the Zambezi.

The occupation of these new stations presented some difficulties since the natives had no knowledge of the hill country. Much time therefore was wasted in trying to find the way to the correct hill-top. This delay caused more trouble than might be supposed, since the necessity of keeping the camp supplied with meat allowed, as a rule, only about five hours during the day for survey, while most mornings and evenings had to be kept for hunting. The ascent of the hills was hard work owing to the large amount of loose rock, covered and disguised by leaves and coarse grass, which made walking in the heat of the day both precarious and irritating. The visibility from the hill-tops frequently proved poor owing to the thick growth of the trees and the hazy atmosphere. As a result, stations would often be occupied and then prove useless.

Heights were obtained by Indian Clinometer and the topography sketched in by the use of formlines at intervals of approximately 200 feet. The plane-table sketch covers an area extending from the western mouth of the Sanyati river to the Nyamachawa river. The remainder of the gorge was mapped by a plane-table traverse with the help of a native dug-out canoe. The plane-

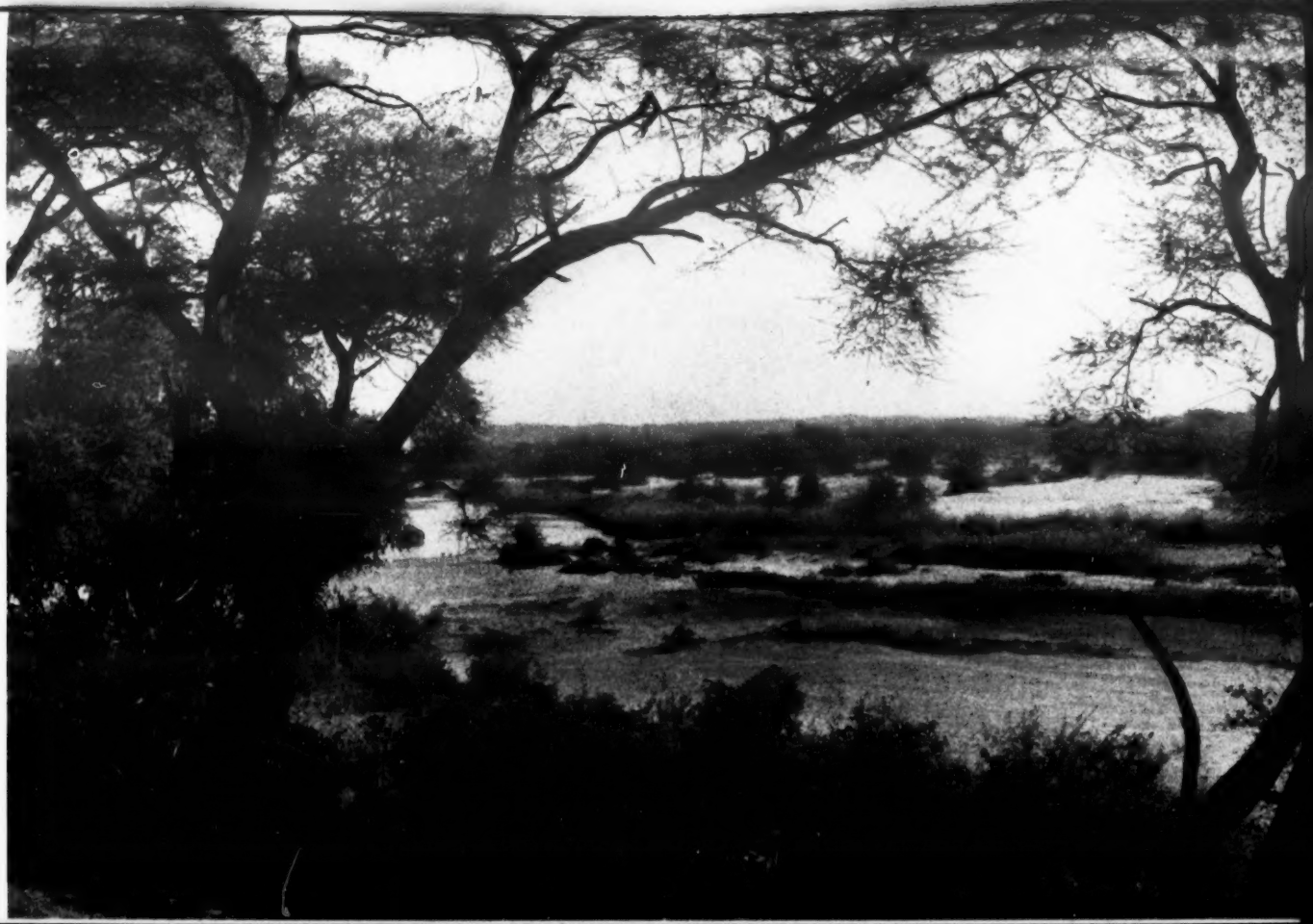
table was set up on the rocks for each sight, but the rate of the canoe was so irregular that much judgment was necessary to convert time into distance for the main lines of the traverse. The canoe was much affected by head winds and the varying speed of the current, while at times poling was necessary, so that the course had to follow the irregularities of the bank. The heights of the hills on either side of the river were estimated and the topography



again sketched in by 200-foot formlines. The names of the hills were obtained from local natives from kraals above and below the gorge.

The Kariba Gorge

The object of the survey was to make a plane-table sketch of the gorge through which the Zambezi flows some 350 miles downstream from the Victoria Falls. The Gorge lies in approximately longitude 28° 45′ and latitude 16° 30′, and is formed by the passage of the river for 17 miles through a part of the Lomagundi system which protrudes into the softer rocks of the Karroo system. The obvious course of the river would seem to be along the soft Karroo beds to the north-west of the harder Lomagundi rocks. The



View from the Kariba camp, looking over the Naodza and Sanyati rivers

C. P. A. S.

Flat country near the entrance of the gorge C. P. A. S.

The Kariba Gorge, looking upstream C. P. A. S.

explanation of its present course may be furnished possibly by the erosive power of the river keeping pace with the gradual intrusion of the Lomagundi rocks which form the gorge. A number of rock specimens were collected throughout the gorge, but owing to an unfortunate accident the exact locality from which each specimen was taken is unknown. For an over-zealous native divided the specimens into one pile and their labels into another! However they all proved to be quartzites of gneissic origin, and specimens have been sent to the Department of Geological Survey of Southern Rhodesia and to the Department of Geography at Cambridge.

It was found practicable to make a plane-table sketch only of the upper reaches, while the lower part was mapped by plane-table traverse. Since it was some time before the necessity for a canoe was realized, together with the usual difficulty of obtaining food for the carriers, only a short time remained for the surveyor to continue beyond the point reached from the temporary camp erected about 4 miles down the gorge. To continue the sketch would have meant the construction of camps in the hills, since it would not have been possible in the short period to have worked from river-side camps, for the surveyor had learnt by experience in the upper reaches that much time would necessarily be wasted in locating and reaching the various stations each day in the rugged and heavily wooded country. Camps however could only be made on the river bank owing to the complete lack of water in the hills. A further delay was caused by the refusal of the carriers to go down the first few miles of the gorge, where walking was possible along the water's edge, to construct the temporary camp owing to their fear of lions, which were plentiful in the hills bordering the river. This difficulty was overcome by the white men making the trip and showing that the natives' fears were groundless. The canoe obtained from below the gorge was a small dug-out, but only one native of experience could be found, as most of the able-bodied men were away earning their tax money. Amongst the carriers, who were mostly from the high veld, only one could be trusted to help work the canoe; the others were frightened at the thought of crocodiles and would undoubtedly have lost their nerve at the sight of hippos, which were met with in considerable numbers in the lower reaches.

The names of the various hills were those given by the natives, but owing to the fact that very few natives ever enter the gorge it seems possible that these names were merely descriptive and were probably invented on the spot. Several explanations of the name "Kariba" were found. One of these was that the word meant "mountains," and referred to the belt of mountainous country into which the river seems to vanish; also it was believed that the word meant "rock," referring to a high rock which was said to have stood at the entrance to the gorge on the Northern Rhodesian bank. From an outside source another explanation was obtained, that the name was that of a natural rock bridge which, so it was believed, used to span the river at the narrowest point of the gorge; however this theory was not supported by local natives.

The entrance to the gorge (approximately 1240 feet above mean sea-level) is connected with Miami (4040 feet) by a rough dirt road which is only passable for motors in the dry season. By this route the gorge is visited occasionally by the native commissioner or by white hunters, but few men have travelled

more than a mile or two down it. Some description of the gorge will therefore be of interest. The gorge may be said to begin where the Sanyati river enters the Zambezi. The Sanyati forks where the Naodza river joins it, about a mile before it reaches the Zambezi, thus forming Sanyati Island. It is opposite the centre of this island that in the dry season the flow of the Zambezi is narrowest and fastest. The surface was measured by the surveyor in August 1934, the middle of the dry season, and found to be only 40 yards wide, although over 1000 yards wide less than a mile upstream. It had previously been measured in April 1927, towards the end of the wet season, when the surface was 97 yards. From this point downstream, during the dry season, the surface widens to approximately 100 yards, though in parts it is narrowed to 75 yards by protruding spits of rock, and remains thus for 6 miles. During the first 5 miles there is a considerable expanse of large water-worn boulders and sand on either side of the water reaching up to the belt of green high-water-line foliage, which forms such a marked contrast to the brown of the hills which make the gorge. The surface then broadens to 200 yards and later to 300 yards until near the exit, when it again narrows to 200 yards before spreading out into the flat country at Nyamuomba Island. The direction of the river during the first 6 miles of the gorge is somewhat north of east; it then swings in a northerly direction and continues slightly east of north. The difference in height of the river between the entrance and exit of the gorge has twice been measured. In 1912 A. J. C. Molyneux measured the fall of the river and found it to be 193 feet from 3 miles above the entrance to the exit. In 1927 the Kariba Gorge Irrigation Survey by corrected barometer readings estimated the fall from entrance to exit to be 197 feet: this was in April at the end of the rainy season. They also noted that flood water had reached 40 feet above the then water-level.

On the Southern Rhodesian side the hills do not start below the east mouth of the Sanyati except for a slight rise of 100 feet on Sanyati Island. On the opposite bank the hills start perhaps half a mile farther upstream and rise from 100–200 feet above the river. The line of the hills which appears to be a continuation of the escarpment which borders the Zambezi Valley rises very abruptly from the flat country. The hills bordering the river banks throughout the gorge are steep but not precipitous. Some of the larger hills do not ascend directly from the river but are separated from it by foothills of several hundred feet in height. Between the high peaks there are ridges of 200–500 feet with occasionally small gorges where streams, flowing only in the wet season, have cut on their way to the Zambezi. On the Southern Rhodesian bank below Sanyati Island the hills rise to 200–300 feet above the river, backed by Tsomo (800 feet); while Karemwe, about 4 miles beyond, is over 1200 feet. From this point they gradually descend and remain at 300–400 feet until the break formed by the Nyamachawa river, some 2 miles farther downstream. This river is dry for most of the year and measures about 50 yards in width where it enters the Zambezi. Close to the Nyamachawa mouth stands Machawa (1600 feet), and at its foot Ntambala, a rock in the middle of the Zambezi about 100 yards long and, in the dry season, about 50 feet above the water-level. The hills on the Northern Rhodesian bank vary from 200 to 400 feet above the water-level for the first 6 miles, while at

one spot they rise to 700 feet, and then appear to rise in disorderly ridges to nearly 2000 feet about 3 miles back from the river. From then on the bordering hills continue with various outstanding peaks such as Nantadzo (600–700 feet) and Kawangombe (1500 feet) on the Southern Rhodesian bank, the smaller Kanyaka (800 feet) and Chamfutira (1100 feet) on the northern side. The actual banks of the river during the lower 12 miles of the gorge consist of steep bluffs and narrow boulder ridges interspersed with sand banks. Here and there a broader patch of sand, mostly covered by thick vegetation and forming a gully between the hills, shows the mouth of some temporarily dry stream. Apparently during the dry season the hills forming the gorge are completely devoid of water save for that of the Zambezi. The vegetation is a thick tree growth of from 20 to 30 feet high, and the only undergrowth is a form of coarse grass covering a surface of loose rocks. Large camel-thorn trees with an undergrowth of thick bushes are found along dry stream courses and along the banks of the Zambezi itself. The flat country of the valley is densely wooded and has a thick undergrowth. To see this difference in the type of country one should climb to the top of Kawangombe from which one gets a fine view of the escarpment running approximately east to west, with the Zambezi winding away to the north until one loses it beyond the Kafue confluence, but can see its direction by the line of the Northern Rhodesian hills over 60 miles away, while stretching away from the river one sees the valley, a mass of trees blurred by the heat haze which is so characteristic of this part. To the south one looks down into the gorge which, seen from this height, seems so much smaller and less grim than from a precarious perch in a native dug-out. Immediately below one can distinguish the fields and villages of the inhabitants. These form the second part of this paper.

The Anthropo-Geography of the Area

The country may be roughly divided on a vegetational basis into those areas which are suitable for cultivation and settlement and those which are not. The determining factors in this division are the nearness to permanent water, the type and fertility of the soil, and the ease with which the bush may be cleared for the planting of the crop. The type of country unsuited for settlement is of three kinds: the rocky mountainous variety of the Kariba gorge and the escarpment; the thick "jese" bush, and the stunted "mopani" forest. The latter is infested with tsetse fly and much favoured by elephant. That which is suited for settlement and cultivation may also be divided into open parkland, and thick forest with large thorn trees found near rivers, which, although the most difficult to clear and keep in cultivation, has good soil and is found near a plentiful supply of water. It also possesses an additional advantage in that the flood banks of the river may be used to obtain a dry-season crop, the seeds being planted in successive rows as the flood diminishes.

It is not necessary for all of the three conditions to be satisfied before settlement takes place, as the advantages of one may outweigh the disadvantages of the other factors. A good example of this is to be found at Mudzimu's kraal, where the ease with which the open parkland is cleared and the small amount of work necessary for its upkeep together with the relative richness

of the soil more than compensate for its distance from permanent water. The village is situated on rising ground, in a type of country usually unfrequented by elephant, above a small river which is dry for at least three months of the year, when water is fetched from the Zambezi about 8 miles distant. However it is common knowledge that there is always food to be obtained at Mudzimu's when the rest of the valley is suffering from famine. Its relatively high situation to the surrounding country of the valley renders it more healthy, a condition which, although it does not influence the natives in their choice of location, undoubtedly has a bearing on their physical and, indirectly, on their mental well-being.

A map showing the distribution of native villages bears out the importance of permanent water supply, as it will be seen that most villages are situated on the banks of those rivers from which water may be obtained throughout the year, although in the wet season a nearby pan may be used in preference to the muddy river. Through this combination of soil and water-supply the bulk of the population lies along the Zambezi, some villages are placed on the banks just above the reach of abnormal floods, while others are several miles inland, very often on or near a stream that flows into the Zambezi and from which water is obtained for most of the year. The Zambezi is the only river in this area which has a permanent visible supply of water, although there are several where water can usually be found by digging in the sand.

This nearness to the Zambezi illustrates the dominating influence of the river on native life. It provides a plentiful supply of fish, and in former times meat in the form of hippo, but both governments have prohibited the slaughter of these animals and impose very heavy fines on offenders. Throughout Rhodesia maize is usually planted in the fields in November with the first rains, but in the valley an additional planting takes place in February and March at the end of the rainy season, which is not possible elsewhere. The seed is planted in the silt brought down by the floods, which provide a fresh supply each year, and the plant is able to obtain moisture by capillary action from the river during the dry months. A continuous supply of food throughout the year is assured by sowing the seed in successive rows as the flood diminishes. It is not unusual to see a river garden where the maize at the highest point is fully ripe, while near the water-level the plants are only a few inches high. Small lagoons are sown with maize as the water evaporates, and islands, which only appear when the river is low, are also utilized. The latter method is only possible with the aid of canoes, and thus one can see the influence which the environment has produced on the material culture of these people. Their neighbours of the escarpment, of the same tribe and speaking the same language, but not needing any form of water transport, have no canoes, and if they do visit the valley they cannot be persuaded to cross the river in one. The style and size of these canoes is very similar throughout the middle Zambezi Valley, but differs considerably from those of the BaRotse, who are river dwellers near the Victoria Falls. There the canoes are much longer and better made. This is possibly due to the fact that the BaRotse have a powerful monarchy and that their hereditary king, Lewanika, demands a large and ornate barge for State occasions. The WaGowa have no powerful central authority, perhaps due to the absence of permanent water, which causes the

C. P. A. S.

Native Department huts at Kariba, used as a base-camp

C. P. A. S.

The narrowest reach of the Zambezi, forty yards wide

A young girl carrying water

Women pounding maize

The owner of a dug-out

settlements to be widely scattered, and canoes play no part in their social and political life, but are merely used for economic reasons and are maintained by their individual owners. Not only is the river valuable for its part in food supply, but it also provides a link between neighbouring villages and also those situated on the farther bank, thus affording a means of exchanging produce and of forming new culture contacts, for the majority of the villages in the Northern Rhodesian valley are peopled by natives of a different tribe, although there are one or two settlements of WaGowa who have migrated from Southern Rhodesia.

This contact with the Northern Rhodesian tribes is well illustrated by the salt trade. Salt is obtained by cutting and burning the grasses which grow in the swampy overflow of a brine spring and which have thus become impregnated. The ash is mixed with water which is then filtered and evaporated, the salty sediment which remains is then fashioned into cakes weighing several pounds. This salt is of good quality and is of much better type than that made by the WaGowa with "guwira," a bush which they burn and then use the ashes without washing them. The salt is either exchanged for fowls or grain, or in some cases natives visit the springs and are allowed to make their own salt, provided that they pay one out of every three cakes to the representative of the chief on whose land the spring is situated. This representative, or "capitao," as he is usually called, is a very important person who directs the tribal salt making and is responsible to the chief. He regulates the amount made by individuals and also limits the use of the spring to certain times of the year. There exists also a considerable trade in tobacco, which is extensively grown for trade in Northern Rhodesia although the government of the Southern Colony has forbidden its importation. It can of course be grown by the WaGowa, but is usually trampled by the elephants unless a careful watch is kept on it. The prevailing rate of exchange is one cake of tobacco, about 4 lb., for a shilling or one fowl. "Masauwu," a variety of fruit similar to a crab apple, which the natives stew and eat as a relish with their porridge, grows on both sides of the river, but on the southern bank is never allowed to ripen as the elephants and baboons strip the trees while the fruit is still very green and unfit for human consumption. It therefore has to be obtained from the farther bank where the natives gather the fruit and press it into cakes which they dry and barter for the fowls of their less fortunate neighbours.

It is interesting to compare the social and economic life of the peoples who live on opposite banks of the river, and to see how the Zambezi, formerly a unifying factor, has through its use as a political boundary by Europeans, produced a tendency to disunification. Near the Kafue confluence there exist two settlements comprising several villages, on opposite banks, whose inhabitants are of the same people and speak the same language, and whose tribal name "WaGowa" ("People of the Valley") shows the unifying influence formerly exerted by the river. Before the advent of the British the geographical conditions which then existed must have formed a single ecological area of the country occupied by these settlements. However differing political and economic conditions have exercised considerable influence and have led to the formation of two separate communities with a marked difference in social and economic outlook. The WaGowa of the northern bank look to

their neighbours, the BaTonga, for exchange of ideas and products rather than to their own people on the opposite bank, who in turn are influenced by their contacts with the other tribes of Southern Rhodesia whom they encounter while away at work. This dependence on foreigners and not on relations can be understood when one examines the external factors which have induced this change. Southern Rhodesia, with a large number of settlers and a marked settler outlook, in 1923 attained responsible government, while Northern Rhodesia, with a comparatively small settler population and before the exploitation of her copper resources, remained under the Colonial Office. This difference in administration and outlook has led to a corresponding difference in policy, the influence of which is clearly seen by a comparison of native taxation in the two countries. In the southern colony the rate is £1 per head per annum for every adult male native and 10*s*. per wife other than the first; while the corresponding figure for Northern Rhodesia is 12*s*. 6*d*. irrespective of the number of wives. This difference is accentuated when one considers that the majority of the males in the northern community find work in Southern Rhodesia, where wages are considerably higher, and therefore are able to earn their tax in a shorter time than the indigenous native. Further restrictions have been imposed by the government on the Southern Rhodesian natives, who have been deprived of the right to own firearms and thus to protect their crops from the ravages of wild animals and at the same time provide themselves with meat, which is necessary for a well-balanced diet. The importance of protection against wild animals, which can only be adequately obtained by the possession of firearms, can be appreciated by one who has lived in both communities. In the Southern Rhodesian villages baboons walk unconcernedly about the huts helping themselves freely from the grain stores and even from the women's grindstones, and unless confronted by a man armed with an assegai will take no notice of human interference. I have seen them chase young boys who have been pelting them with stones in an endeavour to frighten them from the village. Even the women returning from the river with water, should they meet a large troop of baboons in the path, will step aside and wait for the animals to pass rather than face the anger of the tough old dog-baboons. This fear seems partly psychological, an accumulation of human defeats having induced a state of mind which accepts this animal plague as permanent and inevitable. This was not so when the men had guns and were not forced by the exigencies of a government tax to spend the greater portion of the year away from their villages and leave the women to repel and kill the animal intruders, an attitude which is as naturally repulsive to primitive society as to modern civilization. Baboons are not the only animals that endanger the crops. Large buck will feed in the lands at night and elephant will trample and ruin the season's crop in a single night. Deprived of firearms the native has to keep a watch night and day and to use fire to scare away the game, while his womenfolk cultivate the lands by day. In the corresponding area on the opposite bank one sees no evidence of elephant and no baboon-scaring platforms in the lands. The natives there have guns, and, by virtue of a smaller government tax, more time in which to use them. Even an elephant can be intimidated into changing his trampling grounds by receiving at close range in the stomach the shots from half a dozen guns fired by indignant

natives. Baboons are mercilessly hunted should they ever approach the fields or villages, and have to content themselves with food from the natural resources. During my stay in this area I never met an elephant or a baboon on the northern bank, but my camp on the opposite bank was under continual observation by herds of baboons, while the whole country bore evidence of the elephants which at night could be heard feeding and playing down by the water.

That meat is an essential in their diet can be shown in a number of ways, besides the obvious comparison of the general state of health to be found in the two communities. Vegetarianism can and does exist, but for a tribe that has always been accustomed to a sufficiency of meat, this does not seem to be the optimum diet. Before the coming of the British to Rhodesia guns were traded from the Portuguese in exchange for ivory, and the men would spend the greater part of the day in hunting. They laugh at Europeans who confine their hunting hours to the early morning and evening, and maintain that it is easier to wait in the shade of the big thorn trees till the buck come for their midday rest. As I passed through the villages I was greeted by the entire female population who sang and danced round our procession. Wherever I went I always recognized one tune which they never failed to sing and which was an entreaty for meat. Beneath the natural courtesy which demands the welcoming of strangers lies this fundamental desire for meat. This meat urge, which I had observed throughout the valley and which I had exploited as a means of obtaining provisions for my carriers, was forcibly brought home to me by an incident which occurred in this special area. Some women from the Southern Rhodesia village had left early one morning for some shallow pools, several miles down the river, which they proposed to empty and thus to catch the fish which would be left high and dry on the mud. When they arrived at their destination they found a lion at his kill; but he promptly retreated into the long grass at their exclamations of surprise, leaving the best part of a bush-buck. Instead of running away the women took the meat and walked home! I met them on their return and asked them why they had not stayed and fished, to which they replied that they were too frightened of the lion. Yet they had braved the lion at his kill, a thing no European hunter would have dared to attempt. It was too good an opportunity of obtaining precious meat.

No description of the valley would be complete without a reference to the presence of tsetse fly (*Glossina Morsitans*) whose bite, as Bullock aptly puts it, kills man's aspirations to material wealth even where it permits him to live. The fly depends for its supply of food mainly on wild animals, although it can derive sustenance from humans, but owing to their greater irascibility on being bitten, and the quickness with which they brush off the uninvited guest with their hands, the fly prefers to follow the animals instead of remaining near man. This explains why the fly is found in much greater numbers on the southern bank where the game is more plentiful than on the opposite bank where the natives have thinned out the animals with their guns. It is most noticeable when surveying, for I usually found it possible to cover twice as much ground without the unwelcome attentions of the fly. This has, I think, a noticeable effect on the material culture of the people, for one notices that whereas the southern natives spend the heat of the day in sleeping and brushing

away tsetse fly, the northern native spends it in ornamenting his weapons or domestic utensils. It has also a considerable effect on the economic, and thereby on the social life also. Where there are no tsetse one finds dogs for hunting and for scaring wild animals, and goats which, besides providing food and clothing, are the basis of wealth and are used in marriage transactions. Where cattle and goats are found there usually exists some form of "lobola," the Zulu word which signifies the transfer of stock by the bridegroom to the father-in-law, a necessary preliminary to marriage. Owing to the complete absence of domestic animals amongst the WaGowa of the southern colony a different system has had to be evolved. It is one of personal service, for the son-in-law is required to reside in the bride's village and to work in his father-in-law's fields and generally help with other work, in return for which he obtains a wife. This service seems to have no ending except by mutual consent, which would be hampered by the father-in-law's natural desire to obtain the maximum amount of work. Nowadays the young man may obtain his right to move by the payment of a single amount of money, agreed upon before the marriage, in commutation of his service. This can be observed by the increasing amount of patrilocal marriages instead of the former pure matrilocality of the people. However one side of the question has not altered, for unless the payment either in work or in money has been completed satisfactorily, the bride may not be removed from her father's village nor has the husband any right to the children that may have been born.

The general purpose of this paper has been to show, not that the contact of European civilization has a disturbing effect on primitive peoples, but that the difference in application of this contact may produce great divergencies in the same people. It is to illustrate this point that the example of the two WaGowa communities has been stressed rather than a general account of the peoples of the valley, which would be purely descriptive and mainly anthropological. I rather see it as a most interesting politico-geographical problem, that two communities, whose natural outlook is to the river on which they both live and to themselves as members of the same tribe, can be induced to reorientate themselves, the one to look to Lusaka and the north, the other to Salisbury and the south. And this has been brought about by the use of their main unifying factor, the river, as the political boundary between two administrative units, whose policies differ though they are both British colonies.

CENTRAL WESTERN GREENLAND: THE COUNTRY AND ITS INHABITANTS

FRITZ LOEWE

THE subject of the following description is Central Western Greenland and the administrative province of Northern Greenland, before the Smith Sound district was added to it. It extends from the Arctic Circle to 74½° North, from the narrowest part of the Davis Strait which is here less than 200 miles wide, to the region where the glaciers of Melville Bay threaten to overrun the last projecting points of land with their ice.

The polar climate, determined by the neighbourhood of the sea and inland ice, is the main characteristic of the country. It controls the landscape as well as the life of the inhabitants. In May, when the first boat approaches, the coast is frequently still surrounded by extensive fields of ice, the "Vestis" which float across from the coast of Baffinland and, together with the fog which hangs over them, obstruct the shipping. However the fog does not reach farther than the coast, and the inner fjords at this time generally enjoy clear calm weather. In May the sun only just disappears below the horizon at midnight, the average temperature is still just under freezing point and there is frost on most nights in the whole region, but on the southern slopes the rays of the sun penetrate the snow. Blocks of stone, the branches of the dwarf birches and polar willows begin to pierce the snow. The water makes deep cuttings in the melting snow and begins to collect in the flat basins between smoothly rounded rocks. The buntings appear again near the coast after spending the winter inland where there is less snow.

The wind as well as the sun consumes the snow. Near the edge of the inland ice the south-east wind blows pretty regularly and transports the air cooled on the inland ice towards the coast. When there is a strong depression moving towards the north over Davis Strait, the outflow of air becomes stronger, and while on the edge of the coast the damp south-west wind and the heavy seas throw huge blocks of calf ice on to the shore, inland the wind is dry like the Föhn in the Alps and for the same reason; it is warmed by sinking to lower altitudes.

This Föhn "eats" the snow in Greenland as it does in the Alps; it beats in winter and spring on the firm ice with great force, and even in winter when the ice is 3 feet thick, it is sometimes torn and driven out to sea. On such days of Föhn the temperature in all West Greenland, even in winter, may rise as high as 50° F. The strength of these Föhn storms is so great that in one case all the men of a village on the south-east of Disko Bay were swept out to sea when out hunting on smooth new ice. One can tell from a great distance whether the Föhn prevails in the fjords. When it does, great towers of cloud, built up in many thin horizontal layers, stand above the mountains near the edge of the inland ice, showing the stratification of the atmosphere, and their bright shiny edges point to the drying up caused by the descent of the air.

After May the sun never sets, summer has arrived, the last snow-drifts disappear, the ice on the many lakes as well as on the sea breaks up. True, the monthly mean of the air temperature never exceeds 41°–47° F., even during

the warmest months; but the continual sunshine and gentle winds strongly affect plants, animals, and human beings. The smooth rocks which give shelter to the bushes get warm, and above the ice-free, dark coastal region long lines of Cumulus clouds form about midday. The outer coast and the extensive surface of the sea in Disko Bay and North East Bay are at times covered by a flat sheet of fog; but in the inner reaches of the fjords there is nearly always sunshine and a blue sky, and the snow disappears far above the 3000-foot line.

After the middle of August the summer begins to wane, the sun is lower and there is more ground frost. The first feathers of ice appear floating in the sea and on the higher levels new snow remains lying. Now come the autumn rains and with the lowering of the temperature the atmospheric depressions extend farther up Baffin Bay. The weather conditions change quickly. Soon the strong damp south-west wind rushes down the coastal zone and covers the country with snow down to sea-level. Great hurricanes occur on the coast in October and are dreaded by the small coasting schooners, which hasten to finish their provisioning trips before. At the same time the tearing Föhn drives the calf-ice, the icebergs, and the first fields of new ice out of the icefjords.

When the storm drops the frost sets in. The temperature of the snow-covered ground sinks quickly in the clear air and the sun, even at midday only a few degrees above the horizon, cannot compensate for the loss of warmth by outgoing radiation. The ground, only superficially thawed during the summer, is soon frozen and on the beach the belt of the icefoot begins to form.

By Christmas winter sets in. When the days are shortest the sun is below the horizon in the whole territory, but there is twilight at midday even in the north of the Upernivik district. At this time the sea-ice begins to cover the wider parts of the fjords so that the isolation of the small settlements comes to an end and the critical period as regards food supply is over. But now and then the ice is broken up by storms and only after New Year winter sets in properly. On an average the temperature is about −5° F., but it varies a great deal during the winter and also from year to year. The winter is not colder than it is, say, in Winnipeg. Winter is a time of little precipitation: the main amount comes in the late autumn, but even so the total is not very great. The average in the coastal region may not be more than 10 inches, but there is a considerable difference between the inland and the coast although the actual distance may not be great. In the autumn when the ground inland is as yet only thinly covered, the outer coast of Disko, Nugssuak, and Svartenhuk is already deep in winter snow.

In February the sun quickly rises higher and higher. In March it remains ten to twelve hours above the horizon. The deeper snow makes travelling overland by dog-sledges possible, right across the mountain ranges and islands. This is the time for visiting and travelling—connections are good and it is the best season for hunting on the sea-ice. At the end of April the thaw begins. Here and there the ice on the fringes of the coast is loosened by the draining of the snow water, occasionally a layer of fog advances from the sea as far as the coast. Between April and May the temperature rises about 20° F. and the ice from Disko Bay travels out to sea. For the Greenlanders

the spring begins with the appearance of the migratory birds, for the Europeans with the arrival of the first steamer.

To the east of the Central Western Greenland coast the inland ice stretches almost in a straight line from north to south. It isolates the country to the east much more effectively than does the sea to the west, and it is characteristic of the attitude of the inhabitants towards sea and inland ice respectively that the "Good Mother of the Beasts of the Sea" lives in the water and beneficently

supplies man's food, while the interior is inhabited by evil spirits who bring death and destruction to man.

In the southern part of our territory the inland ice rests in a wide front on the undulating country at a height of 1200–1800 feet and is generally accompanied by a huge snowdrift which owes its preservation so far below the snowline to the cooling effect of the neighbouring ice. On both sides of the Nugssuak peninsula the edge of the inland ice becomes more irregular. Structural lines reflected in the surface features of the landscape force its outlets off the straight line. Between 71° and 72° lat. the formation of the

ice edge itself is checked by a great coastal range of mountains, which forces the outflows of the inland ice into narrow, deep-cut fjords. Only farther north (at 72° lat.) where the coastal range is lower does the inland ice regain predominance, covering the contiguous mainland so that only a few promontories and a chain of islands are left between the ice and the sea.

On the whole the inland ice does not belong to these coastal regions. It overflows into them and fills their gaps, but the proper conditions for its formation are not present and even the ice-caps of the coastal ranges in the Northern Umanak district reach nearly everywhere in the neighbourhood of the inland ice so far down that the borderline of highland and inland ice comes down below the snow-line into the ablation region. The influence of the inland ice is shown by its climatic effect, the slope winds preventing the flow of the warm damp air to the inland regions and thus raising the height of the snow-line from the outer coast to the inland ice-edge by 1000–1500 feet. This wind, which carries particles of sand coming from the border moraine or formed by frost action and the cold hard snow crystals, polishes the surface of rocks and boulders as though they had been smoothed with a file. The most striking action of the inland ice on the coast formation is caused by the glacier streams, particularly the large fast-flowing ones which form a striking feature of the coast. Towards the north they increase in frequency: and while they form only an occasional interruption of the normal character of the landscape in the districts of Egedesminde, Christianshaab, Jakobshavn, and Ritenbenk, they are regular features of the country in the districts of Umanak and Upernivik. While in the southern 50 miles of our region the inland ice only reaches the fjords with its outlets in two places, and there the amount of ice thrust off is inconsiderable, in the northern Upernivik district about a third of the coast-line consists of glacier fronts. The size and thickness of these glaciers varies, but they are rarely as small as a medium-sized alpine glacier.

A comparatively small glacier projects along a front about 1 mile wide into the water of the fjord and the wall of ice rises vertically about 100 feet out of the fjord. In summer the melting water pours over the top or flows down the channels which form in the glacier. Several times an hour there is a loud report and a block of ice crashes down—looking small against the huge white wall but actually weighing several thousand pounds. A number of giants dominate this range of smaller glaciers—the fastest known to man. The father of Greenland exploration, Rink, has on this as on so many other points, laid the foundation of our knowledge. He mentions the fact that five of these calving glaciers are particularly active, two in Disko Bay, two in Umanak Fjord, and one in the Upernivik district. Looking at one of these glaciers from a rocky cliff, what strikes one most are its deep clefts and rifts. In the distance the broad ice stream, which is approximately 3–6 miles wide, descends the slope of an amphitheatre in wild seracs and continues its flow confined within a narrow bed. Here and there dark rounded rocks project out of the ice stream, and from these bands of moraine run along it. The enormous pinnacles and crevasses which make such a glacier impassable are probably caused by the deeply penetrating cold and the great difference in pace between the centre and the edge. The front rises vertically out of the water, miles wide, white and shimmering. The observer is unable to judge its size unless he

stands at the bottom of the ice wall, at the top of which great pinnacles of ice are precariously perched. Almost without interruption blocks of ice, great and small, crash down. The time they take to fall seems incredibly long, being in fact more than four seconds. Occasionally a great mass of ice breaks off and comes down with a roar; or a great iceberg, weighing hundreds of thousands of tons, rises dripping and swaying from the deep. An attempt has been made to classify these calvings according to nature and origin and a good deal of discussion has taken place whether the bergs are higher or lower than the glacier front at the time they are formed, but no classification seems possible.

The designation of "Running Glaciers," which has been used for these glaciers, is a very good one, considering that the quickest ones amongst them move approximately 60 feet daily over the greater part of their transverse section—that is about a hundred times as quickly as the biggest Alpine glaciers. The speed and extent of these glacier fronts result in an enormous output of icebergs, which are pushed out into the fjords day after day. The average daily production of ice of the greatest of these glaciers has been estimated at 1000–1500 million cubic feet—sufficient to cover the surface of a square mile with ice 40 feet high. But it seems as though the daily calvings were not sufficient to dispose of the surplus of production for some of the glaciers, and in 1932 it was at last possible to observe the way in which the Rink Glacier in the North of Umanak Bay thrusts off the surplus of its ice once a fortnight. When such a cataclysm takes place approximately 18,000 million cubic feet of ice are thrown out into the fjord, numbers of icebergs, square miles of calf-ice fill the fjord in a few minutes. The greatest waves in the world, 60 feet from crest to trough near the glacier front, race along. The rocks are polished and smoothed high up above the water-mark by the force of the bounding ice, and even at a distance of 20–30 miles from the glacier front the water rises and falls several feet. In this way the fjords are covered with an uninterrupted layer of large and small blocks of ice to a great distance. The tides push the ice about; the large bergs, driven by the Föhn, plough through the shimmering field and finally the current carries the ice into the open stretch of Baffin Bay, where the smaller floes begin to melt. The shapes of the icebergs are infinitely varied, and their position is constantly changed through melting and breaking up. The gleaming white of their pinnacles, the deep blue of the crevasses, and the tender green of the projecting ice-foot form an impressive contrast.

In winter the fjords are frost-bound, and the detached icebergs and calf-ice remain piled in impenetrable confusion until in summer a strong Föhn pushes the whole collected masses out to sea. In consequence, the harbours and channels in the neighbourhood of the settlements can be barred for shipping for some time. The mass of ice drawn from the inland ice by the glaciers amounts, for instance in the Umanak district, to 50,000 cubic feet per second over 125 miles of coast-line. On the same length of coast the German rivers Elbe, Weser, and Ems carry 30,000 cubic feet of water to the North Sea. These glaciers undoubtedly drain a big region of the ice-covered hinterland.

Compared with these outflows of the inland ice the local glaciers play a less important part. Out on the coast, under the effect of the moist sea wind and

not exposed to the influence of the Föhn, the higher levels, above 2600 feet, carry an ice-cap, while in the inner fjords the snow-line rises to 4000 feet and on the southern slopes even 5000 feet. Where dome-like summits rise above the snow-line as at Disko, Nugssuak and in the high plateau regions of the Umanak district, there are extensive highland ice-caps from which glaciers hang over the steep sides of the fjords. But in the wild alpine region about the Karratfjord, a glacier descends each gap, often wall-sided, as if it was glued on to the perpetually frozen slope. In the Kangerdluarsukfjord there are forty-five glaciers on a length of 30 miles, and the majority of them reach the sea. Owing to the climate, which has an average temperature of 15°–25° F., these glaciers are frozen to a great depth and are in consequence less plastic than the alpine glacier, so that their movement occurs through fracturing rather than through fluidity.

Although the climate and ice are in the main uniform throughout the whole region, the formation of the country is sufficiently varied to produce different types of landscape (*v.* map). A stretch of low hills hardly 1000 feet high reaches from Nordre Stroem Fjord to Disko Bay. The valleys, the numerous lakes, and the long fjords follow the joints of the gneiss, while parallel to the coast runs a fence of skerries, projecting only a few yards above the surface of the sea. Only here and there a monadnock stands out distinctly, as for instance the Umanak Rifkol, which forms a landmark 900 feet high. All these islands show in their humpbacked shape the traces of the diluvial ice-cap which may have stretched right to the sea, as it does to-day 400 miles farther north in Melville Bay, only occasionally interrupted by projecting points of land. The coast is sinking rapidly, as is the whole outer west coast of Greenland, but since the Ice Age the sea-level has once been considerably higher. To the south of the south-east corner of Disko Bay there are shore-lines which are 150 feet higher than the present level and contain subrecent marine fossils which require a higher water temperature than prevails now. These clay deposits and the corresponding terraces along the rivers draining the inland ice belong to the rare soft deposits of central western Greenland, as most of the country consists of bare rock, covered only here and there with a thin layer of soil. As the precipitation in this region is very slight the wind occasionally wraps the whole landscape in dust and causes typical loess deposits.

In the region of Disko Bay this lowland sinks below sea-level. Only the slightly raised coastal edge in the west shuts in the great land-locked basin with a few flat islands, and in the northern part only a few isolated reefs lead across to the flat gneissic base of the island of Disko. The land at the east side of Disko Bay rises higher, and is cut in two by the Jakobshavn Icefjord, which is at least 1500 feet deep. Here rounded gneiss hills rise in long undulations above steep valleys and fjords to a height of 1500–2000 feet. Hundreds of lakes, big and small, form a network over the country, and everywhere there are traces of earlier glaciation: striation on polished rocks and isolated blocks on the higher levels as traces of the ground moraine, often in such fantastic positions that it seems as though they had been erected by the hand of man. It is striking how rare these moraine deposits are in the lower parts of the slopes, evidently because they have been removed at a time when the sea-level was higher. The soil structures of the Arctic regions are widespread on the ground,

which is frozen to a depth of 600 feet. Where a mixture of fine and coarse material collects in the depressions one finds the most beautiful polygonal markings. The slopes are striped by the flow of the wet soil over the frozen ground, and in the beds of the rivers the block streams are lifted above the banks by the action of the frost. On the slopes facing the inland ice the smaller blocks as well as the larger hills are smoothly polished by the sweeping snow. A great number of ice-dammed lakes border the edge of the inland ice, and in spring and summer the mud streams of the end moraine run across a permanent snow drift which follows the inland ice. Across the mouth of the Jakobshavn Icefjord lies a shallow threshold at a depth of 800 feet, and here hundreds of huge icebergs cast off by the glacier are grounded and stand in close array on an area of a few square miles.

From the north side of Disko Bay to the southern part of the Upernivik District the outer coast consists of basalt. The alternation of hard lava and softer tuff layers, horizontal or slightly inclined, gives a banded appearance to these great blocks, particularly striking when there is snow lying on the gentler slopes of the tuff layers. Where these massifs exceed the 3000-foot line they are crowned by ice-caps which make the interior of the island of Disko and of the great peninsula of Nugssuak one of the least-known regions of West Greenland.

Elsewhere—for instance on both banks of Vaigat Strait, which is filled with the icebergs of the Torsukatak—the basalt is cut up into fantastically shaped walls. Broad troughs of U-shaped profile intersect these massifs. Where these troughs run from coast to coast as, for instance, to the south-west of Disko, or west of Nugssuak, their origin is difficult to explain. The products of ablation form a smooth beach in front of these basalt walls, thus making the coast harbourless and inaccessible, an exceptional feature on the Greenland coast.

For long stretches however the basalt rocks do not reach down to the coast. There are underlying sediments of upper cretaceous and early Tertiary age, mostly sandstone which is weathering into sand and forming, in the eastern part of Disko and in the middle of Nugssuak, gently rising slopes with soft contours and broad deltas, on the submerged continuation of which the icebergs get stranded. On the east side of Disko one even finds a flat sandy beach. These layers also contain brown coal seams which are worked in a mine on the island of Disko and which are sufficient to supply the demand of Greenland.

The basalt massifs form a landscape of extraordinary grandeur, but as we penetrate towards the north-east of Umanak Bay the impression of overpowering magnificence is even greater. This is a region of huge Paragneiss massifs, bordered towards the east by less resistant mica schists and here we find in the islands and peninsulas huge plateaux, the vertical sides of which fall into deep fjords. There is no sign of a beach for many miles. Ships may anchor close to the foot of these inaccessible walls on which nest hundreds of thousands of gulls and guillemots, but without warning great falls of stones thunder down the smooth walls. On the plateaux are great glacier caps where the altitude exceeds 3000 feet.

In the region of the Kangerdlugsuak—the Great Fjord—and the

Upernivik—the Island of Spring—a little to the north of 71° the plateaux are succeeded by a wild alpine landscape, the highest heavily glaciated pinnacles of which probably exceed a height of 7400 feet—perhaps the highest summits in West Greenland. These mountains, like the plateaux, consist mostly of Paragneiss and are banded by layers of slightly inclined dark amphibolite. It is noticeable that the promontories of the islands and peninsulas facing west show rocks of particularly fantastic shape, probably as a result of the greater exposure to the weather. A great number of glaciers overhang the smooth flanks, find their way into the ravines, and frequently reach the sea. Avalanches of rock and ice witness to the unstable conditions of the slopes; deep fjords and valleys filled with dead ice intersect the deep walls. Hardly anything is known about the development of these parts of the Umanak district. It is clear that tectonic movements have been the cause of the formation of the enormous isolated blocks of the Paragneiss massifs, and we find clear signs that these dislocations actively continue, and that faults still occur on a fairly large scale. One gets the impression that the alpine tracts were cut out of the plateaux and in places one can actually see the transition; for instance, by comparing the north-west and the south-east side of the Rink Icefjord. The effect of the higher diluvial inland ice can be seen not only in undercuttings, facets, and the upper limit of ice erosion on the mountain slopes, but also in the moraine deposits on the sides of the fjords. However not even a majority of glaciations has been definitely proved; even formations which appear obvious at first sight—such as the steep cliff of the Umanak rock resting on a smooth and rounded base—seem problematical on closer inspection. Towards the east the character of the landscape becomes gentler: rounded ice-capped summits which no longer surpass a height of 6000 feet form the transition to the inland ice.

Farther north, in the southern part of the Upernivik district, the rounded gneiss hills which form the background of Disko Bay begin again. The hills barely reach 3000 feet, and in consequence only show inconsiderable glaciation. Here the belt of land is still narrower than it is in Disko Bay, and accordingly the coast is cut up into innumerable islands and peninsulas, ranged on structural lines from south-east to north-west and at right angles from north-west to south-east.

The sea is an integral part of central West Greenland; it penetrates the fjords of the granite region south of Disko Bay and Upernivik district, it fills the broad basins of Northeast Bay and Disko Bay, and in the icefjords it makes contact with the second sea of West Greenland—the inland ice. Flat banks, 100–300 feet deep, belt the coast; but they are evidently crossed by deep channels of a depth of at least 1300 feet, since even the largest icebergs are able to drift into Baffin Bay and currents of warmer water lying at that depth penetrate into the icefjords. These fjords are among the deepest in the world, some of them exceeding 2500 feet.

The bays and fjords enable the caplin, the cod, the migratory seals, and whales to find their way from the high seas to the inner waters. The icebergs travel on these routes in their thousands; they and the smaller calf-ice move up and down them with the tides. These currents gather great force in places, and are of great importance for hunting and travelling. In the narrower

passages which connect two large basins, the tide current becomes a tearing rapid every six hours. Such spots, where even in severe winters the ice never becomes stationary, afford breathing places for seals, and consequently facilities for hunting and favourable places for settlements. Apart from these the greater part of the waterways is covered every winter with a layer of ice. In the northern part, in the Upernivik and Umanak districts, although there is considerable variation corresponding to conditions of temperature and wind, one can depend on reliable ice from January to May, which however rarely reaches far out to sea. Umanak Bay especially, with its smooth surface, undistorted by hummocks, is the best region for sledging on sea-ice. In Disko Bay the ice is not always reliable and the settlements are often cut off from each other for long periods in winter. Occasionally the bay freezes over so quickly that the smaller whales cannot find their way back to the open sea, and they then collect in small holes where they lie closely packed side by side. The news spreads quickly, and from more than 60 miles distant the Greenlanders hurry to the slaughter, blood flows in streams and the memory of it is cherished in lean times.

Altogether it is the sea which supplies the food for the natives. In the whole of Greenland not a single settlement, not even a dwelling, is to be found away from the coast. A little turf and branches for firing, the stones for building the hut, soapstone for the blubber lamp, now and then a reindeer for food and clothing, a few moss berries as a delicacy, the dog to pull the sledge, the isthmus and the inland lake for highways—these are almost the only things a Greenlander of our region owes to the land. The sea supplies everything else. Accordingly one should not relate to the density of the population, which numbers about 7200, of land. It is more to the point to realize that there is one inhabitant to about 2 miles of coast-line; or even more significant that, for instance, in Umanak Bay there are 1500 inhabitants to 3500 square miles of sea, *i.e.* one inhabitant lives upon $2^1/_3$ square miles of water surface.

The boldest of the inhabitants, living on the small islands at the mouth of Disko Bay, venture far out to sea in their kayaks to hunt for the bladdernose and the bearded seal. But on the whole high-sea hunting is less common than it is in the south; fjord hunting is more usual, chiefly because long stretches are unprotected by skerries and the open-sea seals are not to be met with in regular migrations as they are farther south. On the other hand, the winter sea-ice affords special possibilities to the hunters; the old inherited way of catching the animals at their breathing holes, stalking the seal when he is sunning himself; and the new way, spread by the European, catching with nets. The original method of hunting and fishing in this region takes advantage of all the possibilities within the geographical environment. According to the alteration of sea-ice and open water, both Eskimo methods are employed—hunting with the kayak or with the sledge. In contrast to this the method of the South Greenlander on the one hand and the Polar Eskimo on the other is highly specialized, but more limited in scope; the South Greenlander uses the kayak, the Polar Eskimo mostly the sledge. However the traditional Eskimo manner of life is nowhere untouched and perhaps most often to be met with in the isolated fjords of the Egedesminde district. The influence of European commerce and civilization has been active for nearly a

century and is so still. The change is greater in the manner than in the aim of their activities. In a country where agriculture and cattle raising are equally impossible and mineral resources non-existent, there is no room for European standards of living: but European tools and materials have penetrated nearly everywhere—boards for building houses, iron tools instead of stone and bone implements, woven materials for clothing, firearms, iron runners for sledges, European wood for building kayaks, cords and hemp ropes instead of seal-skin straps.

The inhabitants of the present day are no longer of pure Eskimo race—after two hundred years of whaling and colonizing pure-blooded Eskimos are rare, and the official name for the inhabitants is accordingly "Greenlanders," not Eskimos. How considerable is the admixture of European blood it is difficult to determine. It has been strongest in the old centre of whaling round Disko Bay; much less considerable in the fjord districts south of Egedesminde, and in the northern parts of the Upernivik district. The mixed race of Greenlanders shows a remarkable vitality, and forms a strong contrast to the deterioration of other polar tribes. The Greenlanders with an admixture of European blood show the great physical endurance of the pure race, and are generally more enterprising and active than the pure-blooded Eskimos; they are, on the other hand, also more individualistic and less devoted to the community. How high a degree of intellectual achievement men of mixed race can attain is to be seen in the person of the poet and explorer, Knud Rasmussen. The birth-rate of the population of North Greenland approaches 43 per thousand. This exceeds the highest of all European rates. The death rate was reduced to 27 per thousand by the care of the Danish Administration, so that the rate of increase is now 16 per thousand, one of the highest in the world. Consequently the native population has nearly trebled since the beginning of the nineteenth century, while the numbers of Danes has not increased as the whaling stations have disappeared.

This great increase of population and the influence of European civilization even in the remotest regions has raised a number of social and economic problems. North Greenland is according to old Eskimo ideas over-populated at present—extraordinary as this may seem when one thinks of the number of inhabitants quoted above. The indigenous mode of life which depended entirely on the catching of marine mammals cannot maintain the population any more, as the seal catch cannot keep pace with the increase of inhabitants. As yet no decrease in catches is noticeable, though this is the case in the southernmost part of Greenland. Further difficulties arise through the converging of the population round the trading stations of the Danish monopoly which prevents the Greenlanders taking full advantage of the seasonal possibilities of hunting.

These difficulties cannot be overcome by the expansion of the area of food supply. The resources of the country are very limited, and do not admit of a great increase in the numbers of the population. Towards the east the inland-ice forms an impassable barrier. The available coastal margin is almost fully occupied. For a time colonization advanced north of Upernivik, but the extent of the inland-ice in this neighbourhood limits the available coastal region and at present there is only an uninhabitable stretch of 50 miles between

the most northerly habitation of our region and the farthest southern outpost of the Polar Eskimos. The Danish officials do not allow the Eskimos to earn their living outside their own country on European vessels as is usual in the Hudson Bay waters—the principle being to protect the indigenous population from dangerous influences, which they cannot check or control.

The only alternative of enlarging the field of possibilities is the high sea. But such extension is not possible within the limit of old Eskimo methods. The assistance of the Government will be needed to supply the population with motor boats which would make it possible to tap the great wealth of fish on the banks along the coast—a development which is already taking place in South Greenland.

Finally there is a possibility of deep-sea fishing, and in this direction a good deal is being attempted. Seal fishing with nets under the ice has most likely been known to the old Eskimo tradition; but only during the last century have the nets supplied by the Danes made net-fishing the most important source of winter food supply. The use of long hemp fishing-lines makes it possible to tap the wealth of fish in the deep waters of the fjords. It is mainly a question of fishing for Greenland shark, the flesh of which is suitable for dog food, the liver a valuable article for trade. There is also Greenland halibut, which serves as food for the dogs and is dried and salted for human consumption. Besides these the cod has occurred in great quantities in our territory during the last few years. During the last hundred years it was found only in Southern Greenland, but in the last fifteen years it has appeared in shoals farther and farther north. Since 1919 it is found in the Godthaab district, in 1929 it crossed the frontier of our territory and reached the inner part of Disko Bay, and in 1931 it appeared in the Umanak district, though in smaller numbers it is true. Probably slight alterations in oceanic conditions are the cause of this most important economic change. The cod catch in the central West Greenland has actually multiplied a hundred times in the last fifteen years, and amounts to-day to over 4,000,000 lb. a year.

Such a change of the conditions of life cannot occur without causing deep changes in a social structure chiefly based on, and delicately adjusted to, the scanty possibilities of Arctic conditions as is that of Greenland. Under the old conditions of life in Greenland the hunter was the mainstay of the community. Aided by an elaborate inherited technique, he hunted the marine mammals which supplied nearly everything needed to maintain life. He ventured out in his kayak and dog-sledge, leading a life of danger and hard work. He was a person of importance, the undisputed leader of the community, whose existence depended on his sharp eyesight and his strong arm, his courage, and his readiness to risk his own life. The fishing was done by boys who could not yet manage the kayak, women, and old men, the unfit, all those who were too weak for the life of the hunter.

The great increase in population during the second half of last century caused the catch which remained more or less stationary to become less and less adequate to satisfy the requirements of existence. At the same time the decline in the value of blubber, through the use of paraffin, forced the Government to try to cover the expenses of a far-sighted policy of education by other means. Trade with fishing products developed; an attempt was made to

educate the Greenlanders in rational fishing methods and their catch was bought. Now it appeared that—given a suitable locality—a fisher could arrive at comparative comfort according to Greenland standards with much less danger and labour than the seal hunter. And this development, beginning in the south, applies now also to North Greenland, up to the northern parts of the Upernivik district. Thus Jakobshavn, once notorious for its poverty, has become, with its population of 550, the largest and richest colony of our territory owing to the abundance of Greenland halibut on the bank in front of the icefjord where the icebergs go aground and, through ablation, deposit quantities of ground moraine with its rich nutritious components. In connection with this development the importance of dog-sledging has begun to diminish. The fisherman need not go so far afield as the seal hunter—a good team needs a great deal of food and its education requires patience and effort, so that if sledging had not the attraction of a sport for the Greenlander, the standard would quickly decline.

The inhabitants of north-west Greenland have accordingly arrived at a stage where an "inversion of valuations" is going on—in the economic sphere as well as the social. From being a self-supporting community whose existence largely depended on natural resources, they are becoming a unit in international economics, based on currency and trade. This is the greatest test of the vitality of a people and of the value of its social order. It may seem a tragedy to us that once again the harmony between man and nature will be destroyed, and a veneer of European civilization be spread also over this country. But this development cannot be arrested. Only the care of the Danish Administration makes it possible to maintain the balance between the food supply and the increase in population. If one left the Greenlander to his own devices and ways of living and abandoned the present beneficent policy he would soon be faced with starvation, poverty, and epidemics. The Greenlanders may consider themselves fortunate to have the government of the "Grønlands Styrelse" at this critical period of change. The leading principle of the administration is the carefully planned transition of Greenland life to European civilization, in a form suitable to the nature of the country and its inhabitants. This aim has long since outweighed the consideration of material gain.

Greenland has been kept almost completely isolated from the rest of the world—even from Denmark—so as to shield it from epidemics and undesirable influences. There is a strict monopoly of trade, which excludes many things which might have a weakening influence on the health and vitality of the Greenlander, as, for instance, alcohol. On the other hand, he can obtain goods which he is encouraged to use, such as fishing utensils, at a very low price. It is true that the price he gets for his catch is also determined by the Government, and generally much below the world market price: but on the whole this arrangement benefits the Greenlander. The aim of the Administration is to develop a national type of culture by providing schools and maintaining the Eskimo language, and thus limiting the Danish influences. In consequence of far-reaching hygienic measures there have been fewer epidemics, a decline in mortality, and the increase in population mentioned above.

What road will the inhabitants of our territory take? Will they be able to

preserve their race and their tradition? The prospect is favourable, more so than for most Arctic tribes. The economic change and the use of money is sure to weaken the cohesion of family and community which saw to it that nobody begged or starved while the neighbours had plenty. But the traditional spirit of comradeship and self-sacrifice will surely survive and receive a new impetus from the living spirit of Christianity which prevails among the inhabitants. The continuing but diminished admixture of European blood will add to their energy and initiative—all the more needed now that the population is on the increase, and might easily get pampered through the care and forethought of the Danish Administration. It is to be hoped that a wise guidance will achieve the right balance between the old traditions and way of life and European culture, between freedom and grandmotherly government.

The old Greenland is passing away. A wireless station rears its masts at Godhavn, the capital of North Greenland, and connects the country, formerly isolated for six months of the year, with Europe, and the settlements with the central administration. In the "Landsraad," the Parliament of Greenland, people begin to complain that the noise of the motor boats drives away the seals. The old skin tent, the large light "Umiak" made of sealskin, are rarely seen even between Holsteinsborg and Upernivik. The first aeroplanes have appeared, and the inner fjords which are generally free from fog will gain in importance as air ports. But the old Eskimo way of life will not disappear entirely: dog-sledge and kayak will continue to be used for centuries for obtaining food and serving communication. It is beyond the power of man to change this country by his activities, as he has done in more favoured regions. The influence of man and his works will remain almost imperceptible in the grand forbidding landscape of Central Western Greenland.

AMUNDSEN'S LAST JOURNEY

ROALD AMUNDSENS SISTE FERD. By GUNNAR HOVDENAK. Med et Tilleg om Krassin-Ferden, av ADOLF HOEL. *Oslo: Gyldendal* 1934. 9½×6½ *inches; 304 pages; illustrations and maps*

ON 25 May 1928 General Nobile's expedition with the airship *Italia* met with a disaster while returning to Spitsbergen from a flight to the North Pole. One of the efforts planned to rescue the survivors was the Norwegian explorer Roald Amundsen's: his expedition was of his own initiative and supported by private funds. With a French seaplane, manned by a French crew, he left Tromsø in the afternoon of June 18 for Bear Island or Spitsbergen, but never arrived.

Amundsen's interest in the use of aircraft in the polar regions was of very long standing and went in fact back to the day he heard of Blériot's crossing of the Channel in 1909. He had planned to have a machine with him on an expedition on the *Fram* in 1914, but the war put a stop to the project. He tried again in 1921 during the drift expedition with the *Maud;* but one of the Junker aeroplanes was damaged on the way to Seattle and its replacement was wrecked while trying to land on the pack-ice of the polar basin. The idea of a flight from Alaska to Spitsbergen was however still in his mind. He next turned to flying-boats and in the summer of 1925, with the support of the American Mr. James W. Ellsworth, he attempted to reach the Pole from Spitsbergen in two small Norwegian machines. The expedition reached 88° north, but had to spend three weeks in the ice before making Spitsbergen again. Flying-boats did not seem to be suitable aircraft for flights over the polar basin.

During the next year, 1926, the Amundsen-Ellsworth-Nobile crossing of the polar basin was made in an airship. The dirigible was Italian and Nobile was not only its constructor, but also its commander. The main object was thus achieved, but the very achievement led to an undignified wrangle for honour. Aggravated by national pride and international misunderstanding, both men were led into a quarrel from which nothing was gained but bitterness. Nobile made no secret of his ambition to fly to the Pole in his own airship under his own national flag. This was the ambition realized in 1928.

As soon as the disaster to *Italia* was known of, Norway offered to arrange a rescue expedition. But such an expedition, of which the leadership had been offered Amundsen, was not deemed desirable by the Italian Government. Certain reconnaissances were however put in hand by the Norwegian Government and magnificently carried out in the face of difficulty and danger by the pilots Riiser-Larsen and Lützow-Holm. Exactly why Amundsen, now a man of fifty-six years, still wished to go himself to the rescue of Nobile is not a problem within the scope of this book or its review. Nevertheless the sluggish progress of the international rescue efforts must have made a disturbing impression on anybody able to imagine the predicament of the survivors. One of the pilots from the 1925 essay, Dietrichson, did his best to assist in the search for funds and a machine. But on June 13 the press announced that the appeal had failed, and that the plan must be abandoned.

There the matter would probably have remained but for the energetic patriotism of Scandinavians abroad. A Norwegian business man living in Paris, named Peterson, read the news. By the 16th, through his efforts, a French naval seaplane, the *Latham* 47, had started with a French crew from Caudebec-en-Caux for Bergen. On June 18, at four o'clock in the afternoon, she started for Spitsbergen from Tromsø. On board were Amundsen and Dietrichson, in

addition to the crew of four under the command of Capitaine de Corvette René Guilbaud.

As soon as it was quite clear that another major disaster had occurred a new search was put in hand. This was in some ways more difficult than the search for the *Italia* survivors, the possibilities being less defined. At the time of the second disaster Nobile himself had been fetched by aeroplane, the position of the other Italians was fairly well known, and the Russian ice-breaker *Krassin* was already on the way to their relief. The organization which now had to be set into motion to search for Amundsen and his comrades was fantastically complex. Almost all the vessels known in the literature of contemporary arctic exploration took part. There were the *Quest*, *Heimland*, *Veslekari*, *Hobby*, *Michael Sars*, *Pourquoi Pas?* and even the *Gustav Holm* for a short time. In addition the French sent up the cruiser *Strasbourg* and a fishery inspection sloop the *Quentin Roosevelt*, while the Norwegians put the battle-cruiser *Tordenskjold* at the service of the search. It is at this point that the author, a captain in the Norwegian Navy, was appointed as liaison officer in the *Strasbourg* to take a part in the investigations he describes. The *Strasbourg*, commanded by the French Admiral Herr, became the flagship for the direction of the whole scheme of search. The sailors of the two nations went competently to work in a cooperation that seems to have been free of friction or incident for the whole period. The excellence of Captain Hovdenak's description of the series of events of that summer is perhaps a reflection of his qualities as liaison officer. The very complicated sequence in the combing of the Greenland and Spitsbergen waters is laid out clearly and continuously, so that, so far from being confusing, the narrative maintains without irrelevance an unbroken interest through the entire book.

When Captain Hovdenak gives judgment, it is with enormous care. He finds it, for instance, to be in order that General Nobile should have allowed himself to be rescued first. The comparison of the situation with that of a sinking ship is, he holds, false. "The master of a disabled ship has two tasks: not to forsake the goods and the vessel entrusted him so long as there is any possibility of salving them; and to see that all on board leave the ship safely should she have to be abandoned. Both these tasks are best undertaken by the master remaining on board till the last. The ice-floe however on which the Nobile group found themselves was no entrusted property which had to be salved; and the presence of the severely wounded leader" (he had a wounded head, a broken arm and a bad fracture of the leg) "so far from reinforcing the group's chances of rescue, reduced them."

But Nobile is criticized for his rashness in disregarding the weather reports from the Geophysical Institute in Tromsø. He had had a warning in a preliminary flight over Franz Joseph Land, during which, although cautioned against it, he had continued steering eastwards until dangerously bad weather was encountered. In the same way in the final flight advice was given not to pass eastwards of the meridian 10° east, but to bear over towards Greenland on both the outward and return journeys. After reaching the Pole Nobile laid a course direct for Spitsbergen.

Miss Boyd is given a warm tribute for the generosity with which she put her expedition at the disposal of the search, for the endurance shown in living in uncomfortable conditions through a stormy and frequently dangerous summer, and for the tact she displayed in handling the situation on a Norwegian sealer, chartered by Americans of which two were ladies, skippered by one Norwegian, piloted by another, conducted by a Scotsman spending his 22nd summer in the Arctic, and having on board Captain Riiser-Larsen as representative of the

search. "It was indeed an absolutely unique circumstance that a woman should function as the leader of an expedition under the general command of an admiral, or, properly speaking, of two admirals, who did not even belong to the same nation."

The author is no less careful in the discussion of facts. The elucidation of what actually happened to the *Latham* 47 was directed as brilliantly in the field as it is ably discussed in the book. The methodical search over vast areas of sea and the examination of all possible places where a man might have landed could not be done haphazard. But as the summer went on without bringing any news it became clear that the end had been catastrophic. There were many who believed that Amundsen would suddenly appear again and found it hard to accept the indications even when at length first one of the wing-floats and then a petrol tank were picked up. By gradually assembling the evidence of ships' log-books and fishermen's memories it was revealed that a lane of north-easterly wind accompanied by fog had been blowing down the sea between Norway and Spitsbergen, but in such a way that none of the reporting stations could detect it. The weather before, during, and after the flight had been fine both in Norway and Spitsbergen. Parenthetically it may be remarked that the publication in full of the letters of the fishermen, who in their own way and without affectation describe Amundsen's course seawards, has a dramatic effect which the author himself cannot have foreseen. The reproduction of the exact phraseology and orthography touch the reader personally and unexpectedly.

The *Latham* 47 was not equipped for continuous periods of blind-flying and was probably forced down after one or two hours of being in the fog. The evidence of the two pieces of wreckage pointed to the machine having sunk within a few instants of landing in a heavy sea. "One can mourn the fate of the four Frenchmen and Dietrichson, taken while life still lay open before them. But for Roald Amundsen it was otherwise. He had sailed through the North-West and the North-East Passages and had reached both Poles. There seemed to be no great conquests left within the field of his abilities; criticism and bitterness had begun to cast a shadow over his life. It cannot indeed be denied that the unfortunate dispute with Nobile had taken some of the brilliance from Amundsen's name. But the *Latham* expedition more than restored that which was lost. By resolutely putting aside former disagreements and, with his life at stake, hurrying to Nobile's rescue Amundsen brought new honours to his own and his country's name; as a hero surrounded by his glory he entered the fog and disappeared, on the way to the regions where he had wished to rest."

M. S.

REVIEWS

EUROPE

WHY PICCADILLY? The story of the Names of London. By E. STEWART FAY. *London: Methuen & Co.* 1935. 7½×5 *inches;* xii+254 *pages; illustration and plans.* 7*s* 6*d*

The street names of an ancient city are often the only relics of events, customs, or personages that have otherwise left no record, and even comparatively recent names are not without interest. The area covered by this book represents a long history of building: it extends from Tower Hill on the east to Park Lane and Sloane Street on the west, and never goes south of the river and seldom far north of Oxford Street. The author starts from Piccadilly, and after dealing with Mayfair, Pimlico, Westminster, St. James', and Soho, passes by the Strand and Covent Garden to legal London and the City, where the interest reaches its climax. An idea of the enormous number of names noticed in the volume may be conveyed by the fact that the index covers over eleven pages with two columns to a page. The temptation to begin quoting derivations, especially those which differ from the apparently obvious, is great and must be resisted. In cases of disputed origin, like Pimlico, the author lets the reader take his choice. He remarks the virile character of certain names; Holborn for instance, a small brook, named a street, viaduct, circus, and ultimately a borough. It is surprising to learn that Piccadilly Circus was once Nash's "Regent Circus"; the latter name certainly belonged not long ago to the present Oxford Circus and was painted on the wall there before the recent rebuilding.

The author makes some pertinent observations on the naming of new streets, and calls attention to the outbreak of "Avenue" disease in the City and the substitution of this pretentious misnomer for the good old word "Alley." A greater cause for complaint is the false archaeology of a name like Roman Bath Street, if it is true that the bath commemorated was Turkish and not Roman. The Westminster Council is commended for labelling its streets with names of Deans and others connected with the Collegiate Church of St. Peter. We may be inclined to agree that, if in a newly built suburb no traditional names are available, the "soulless" principle of giving streets ordinal numbers on the New York plan is preferable to that of naming them after characters in Shakespeare or Dickens. The former system has the advantage of enabling a stranger to find his way about, whereas Romeo Street conveys nothing to him. Perhaps Washington has hit on the ideal scheme for a new lay-out: first names of one syllable in alphabetical order, then of two—Adams, Bryant, Channing, etc., then of three—Allison, Buchanan, Crittenden, etc. But names with a genuine local connection are best of all, as this book illustrates over and over again. It is a fascinating exposition, though the author occasionally becomes rather unnecessarily chatty; he can make the subject entertaining enough without recourse to facetiousness.

J. H. R.

THE DORSET LANDSCAPE. By GEOFFREY CLARK and W. HARDING THOMPSON. (The County Landscapes.) *London: A. and C. Black* 1935. 7×4½ *inches;* xii+116 *pages; illustrations and maps.* 5*s*

The County Landscape series, in which four volumes have now appeared, is in the words of the Introduction "an attempt to interpret the character of the English counties through their physical features." The authors are well-known workers for the Council for the Preservation of Rural England and,

while showing what is best worth preserving, approach the subject in no bigoted spirit of opposition to all innovations. They do not recoil in horror from car-parks or pylons. Few people now are repelled—some are even thrilled—by the sight of telegraph wires running along a main road; we shall soon grow equally accustomed to power-wires bestriding the country on their lawful occasions. Bungalows, whether seaside or inland, need not be blots on the landscape. It is the unregulated broadcasting of these works of man that is the real bogey; there are certain regions of England that should be made entirely immune from them.

Few counties have so many "unspoilt" areas and so great a diversity of rural scenery as Dorset. It is the work of the authors to analyse the various landscapes, and they point out their relationship to those of neighbouring shires. After chapters on county characteristics, the geological foundation, and the human contribution they proceed to a careful study of the eight "features" of the county—chalk uplands, heathlands, Purbeck, Portland and the Chesil beach, west Dorset, Blackmoor, east Dorset, and the rivers. A few notes on the highways, lanes, and footpaths are followed by a section on local building-types under the heads of towns, villages, churches, and manor houses. Dorset may not be so rich in ecclesiastical architecture as certain other counties, though the list of churches in the appendix includes some fine examples, but it is second to none in its wealth of manor houses, whose very names are, in the authors' words, "a string of musical syllables surpassing in melody even their architectural cadences."

The contents of the book are summed up in the highly coloured folding map which will be found in an end pocket. Besides heathlands, woodlands, and river valleys an attempt is made to show "areas of special landscape value"; it is noteworthy that the latter include practically the whole of the coast line, and there are indeed portions of this strip, as in the Isle of Purbeck and between Bridport and Lyme Regis, that well deserve to become national parks. The map also indicates those towns and villages that are characteristic and of special beauty. Churches of particular interest and the principal earthworks are marked with red crosses and circles, while red arrows show fine view-points, such as Pilsdon Pen, Bulbarrow, and Melbury Hill in the central uplands and many spots in Purbeck. It is a not unsuccessful piece of special cartography. J. H. R.

THE CENTRAL HIGHLANDS. Edited by H. MACROBERT. *Edinburgh: The Scottish Mountaineering Club* 1934. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 158 *pages;* 2 *photogravures,* 49 *photographs,* 14 *line diagrams,* 2 *maps.* 5*s*

THE ISLANDS OF SCOTLAND (excluding Skye). Edited by W. W. NAISMITH. 136 *pages;* 42 *photographs,* 9 *maps,* 1 *photogravure,* 9 *line drawings,* 3 *panoramas.* 5*s*

The volumes of the Scottish Mountaineering Club Guide contain very much more than mere directions to the rock-climber how to tackle Buttress *b* or No. 2 Gully. In fact they do little more for him than tell him how to find these objects of his heart's desire and what quality of climbing he may expect there. All lovers of Scottish mountains, whether they wish to scale them by their steepest precipices or to walk up them by their easiest ridges or, for that matter, to admire them from their far-flung bases, can nowhere find better general information than in these S.M.C. guide-books. They are splendidly illustrated with photographs of scenery, the boldness of which will surprise many even of those who are no strangers to Scotland, and they are well equipped with sections of Bartholomew's excellent $\frac{1}{4}$-inch map.

The two volumes under notice deal with regions very different in character.

The Central Highlands here include all the heights south of Loch Linnhe and the Great Glen as far as Ben Cruachan, but exclude Ben Nevis and the Cairngorms, which have volumes to themselves. Outstanding among them are the splendid group round Glencoe and some fine peaks in the Mamore Forest. Most of the photographs appear to have been taken in mid-winter and show scenes that might easily be taken for Alpine. Some of the subjects are flattered by this treatment: snow is an enormous improvement to a Ben as deficient in crags as Cruachan. Some views along Áonach Eagach, the Notched Ridge, on the north of Glencoe might be included in a second edition; it is admitted to be unequalled among ridges on the mainland. Mr. Macrobert tells us the meaning of names and occasionally attempts an explanation of their pronunciation. Perhaps a Saxon should not rush in where a Gael hesitates to tread; but the reviewer's experience is that *coire* and *choire* are not both pronounced "corrie," the second being more like "horrie." The pronunciations of some Gaelic names are almost beyond belief; the remark "*pron.* Ula" against Beinn Fhionnlaidh passes that limit and should surely be transferred to the adjoining Sgor na h'Ulaidh.

The volume on the Islands is even more valuable than the other to the general tourist; certainly no visitor to the Outer Hebrides should travel without it. Except Skye, which naturally monopolizes a separate volume in the series, practically every island in Scotland comes under notice, even though rock-climbers may find no scope for their activities on some of them. There is evidently plenty of rock on the "vals" of Rum and Harris, but the best climbing ground described in this volume is the small group of peaks in Arran, though granite provides a rather special form of the sport. Orkney, Shetland, and St. Kilda have many remarkable sea-cliffs, the home of innumerable birds who hardly seem likely to suffer frequent disturbance from nailed boots. J. H. R.

CLIMAT SOLAIRE DE NICE ET DE LA CÔTE D'AZUR. By LADISLAS GORCZYŃSKI. Mémoire IV de l'Association des Naturalistes de Nice et des Alpes-Maritimes. ("Riviera Scientifique," années 1933–1934.) *Nice: Association Typographique* 1934. $9\frac{1}{2} \times 6$ *inches;* viii + 208 *pages; illustrations*

The Côte d'Azur, protected from cold northerly winds by the mountains, washed by the waters of the Mediterranean, and warmed by plentiful sunshine, is so unique in its conditions as to merit special study. In this book L. Gorczyński has made a detailed study of the amount of solar radiation measured at Nice and Antibes, and has compared this with the corresponding observations at Paris and Warsaw. In the first and sixth chapters the author has described in some detail the instruments used in the measurement of direct sunshine and of the radiation diffused from the sky, the exposure of these instruments, the details of the recording apparatus, and the methods of reduction of the records obtained. This information is not usually readily to be found, and it is all the more valuable to have an adequate description by an expert in the subject, one who has himself made valuable contributions to the instrumental equipment of the solar observatory.

A chapter on the astronomical aspects of the subject deals with the length of day and of twilight, the altitude of the sun at different times of the day for a number of selected days during the year, the times of sunrise and sunset at Nice, and a number of other factors, all shown in a series of tables. The next chapter discusses the actually observed mean duration of sunshine per month at Nice, Antibes, Beaulieu-sur-Mer, and Cannes, with a comparison of mean duration of sunshine and cloudiness. The mean cloudiness at Nice is least in August, about 3-tenths, and greatest in April, about 5·2-tenths, with a second maximum of about 5·1-tenths in October.

The discussion of the transmission of the atmosphere is shown in the next chapter to be higher at Nice, particularly in the winter months, than at Paris or Warsaw. The fifth chapter is devoted to a discussion of the pyrheliometric measurements at Nice and at Thorenc in the Alpes-Maritimes, and a comparison of both stations with Paris. The excess in the measured intensity of radiation at Nice over that at Paris is particularly marked in the months November to January. At Nice the annual variation of the maximum intensity of solar radiation varies little from month to month, while at Paris there is a variation of about 30 per cent. from minimum to maximum. At noon in clear weather the direct solar beam at Nice has an intensity of from 1·24 to 1·35 gramme calories per square centimetre per minute, which should be compared with the estimated intensity of the solar beam at the outer limit of the atmosphere, 1·94 in the same units. The radiation diffused from the sky increases the noon radiation falling on unit horizontal surface by 20 to 30 per cent., and the ratio of the diffuse to the direct radiation increases as the zenith distance of the sun increases. There is an interesting table on p. 174, which shows that in clear weather the amount of diffuse radiation falling on unit horizontal surface is substantially the same in France and Poland, and presumably elsewhere, for equal altitudes of the sun. With an increase in cloud amount comes an increase in the amount of diffuse radiation.

The final table in the book gives for the months of December and June, and for each season, the total amount of radiation (direct and diffuse) falling on unit surface for the Côte d'Azur, Zugspitze, three stations in the United States, four stations in the centre of Europe and three stations in north-western Europe, showing that at all times of the year the Côte d'Azur has a higher total of incoming radiation than any other station named. This table is really impressive, and forms a fitting conclusion to a very interesting and carefully written book.

D. B.

ASIA

PAINTING IN THE FAR EAST: An Introduction to the History of Pictorial Art in Asia, especially China and Japan. By LAURENCE BINYON. Fourth Edition. *London: Edward Arnold & Co.* 1934. $10\frac{1}{2} \times 7\frac{1}{2}$ *inches;* xvi+302 *pages; illustrations.* 35*s*

'Painting in the Far East' was first published in 1908: it still retains all its value as an introduction to the art of China and Japan. For Mr. Binyon possesses, in addition to knowledge, the talent of describing in prose the values and the effects of pictures. There have been many prose writers, Pater and Ruskin among others, who have attempted the same task, but there is an egotism and extravagance in their attempts which obscure rather than illuminate their subject. Mr. Binyon, whose writing has a delightful sobriety, succeeds better in his difficult task of translating the extraordinary vitality and charm of the art to which his book is devoted. Like the artists he analyses, he is both a poet and a scholar.

This new edition of his book has been revised throughout. The second chapter especially, on "Early Art Traditions in Asia," has made use of the enormous increase in our knowledge due to the numerous missions which followed Sir Aurel Stein into Turkestan—the "little remote kingdom in the heart of Asia" where "we touch three great civilizations at once: India, China, and Greece." Here, as Mr. Binyon says, "Apollo transforms himself into Buddha." But long before Buddhism became a factor in Chinese culture, Chinese art was fully developed: the material gathered by the missions in Central Asia is contemporary with the greatest period of Chinese Art, that of the T'ang Dynasty.

The later chapters have gained also by the increasing accessibility of works in China and Japan and by the growth of the great European and American collections: and also by our increasing knowledge of the works of the T'ang period. Yet, as Mr. Binyon confesses, many of the greatest artists are still merely names. No work of the great Wu Tao-tzŭ is known certainly to survive.

There has been not only an increase of knowledge, but a change of taste which has unduly depressed the reputation of the Japanese. Mr. Binyon's values are proof against this vagary of fashion and his account of the relations between China and Japan reveals its extravagance. He is as sensitive as he is sober in his judgments: and the union of these two qualities gives his work a permanence which few introductions achieve. M. G. R.

BETWEEN THE OXUS AND THE INDUS. By Colonel R. C. F. Schomberg. *London: Martin Hopkinson* 1935. 9×5½ *inches;* 276 *pages; illustrations and map.* 15*s*

Many of us have waited long for such an account as this of the fascinating country and people round about the Indus valley, and we must commend Colonel Schomberg for conveying his traveller's impressions in such an able and charming manner. After reading this book most readers will want to visit these rapidly-changing peoples, because we know that what the author recorded of them in 1933 is fast becoming a phase of the past. The greater part of the book contains the author's impressions of the Gilgit Agency and as this district has for a long time been a source for controversy, as visitors are rare and not encouraged, this book will be readily accepted by those who want authoritative information. The author has very sound, though often amusing, ideas of the political situation which are woven into the book in subtle ways.

The first section deals with the travelling experiences from the Gilgit Agency through the Punyal, Yasin, and Hunza, which is delightful reading: and the reader is struck by the able word-pictures—"a dingy shrub, due partly to its habitat in dusty, open fields and partly to its dull green colour, the tamarisk is rarely impressive, but here it was a beautiful, delicate, lace-like growth, filling the whole expanse with colour, and standing out against a background of light green fields."

It would be, I think, correct to say that this book has an equal value anthropologically and geographically; for the portraits of the people with whom the Author comes in contact and his shrewd judgment of their characters are remarkable. Five chapters are devoted to the inhabitants, their customs and folk-lore, and are equally enjoyable as the geographical impressions. Schomberg constantly refers to the 1933 political situation, as seen from the point of view of the peasant; and the thirteenth chapter is an account of the Hunza-Nagir War. Seventeen pages, in the form of an Appendix, on the History of Gilgit, Yasin, and Punyal respectively make an interesting conclusion to a most delightful account of conditions between the Oxus and the Indus. There are also numerous beautiful photographs taken by the Author and a very useful map at the end. J. A. W.

THE GLORIES OF HINDUSTAN. By Ernst Alfred Nawrath. *London: Methuen & Co.* 1935. 8½×6½ *inches;* xvi *pages*+240 *plates* [*with notes*]; *illustrations and sketch-map.* 25*s*

Mr. Nawrath has produced a remarkable book, and the secret of his success lies in the firm foundation which has been given to his artistic judgment by his affection for India, his sanity, and his technical ability.

The book consists of 240 full-page photographs, each with a short explanatory note containing cross references. The photographs are admirably taken and include groups, scenic effects, and architectural objects whose great beauty lies

both in close-up detail and in the broader aspects of complete design. The groups and scenic effects are well chosen, and as full of local atmosphere as is possible when employing a medium which can never represent the squalor inseparable from certain aspects of the East.

Mr. Nawrath begins with a good map, an important aid to those who, fired by the wonders which he reveals, may determine to see the originals themselves. He also gives very useful technical and other hints in his explanatory note and Preface; but unfortunately there is no index.

Plate I shows a perfect statue of Buddha, while Plates XXIII to XXVI, XXXIII to XXXVIII and LVIII of Bhubaneswar temples, the Black Pagoda, Kanarak and the Chaturbhoj Temple, Khajraho illustate the unequalled capacity of the ancient Oriental architect to blend successfully grandeur of general design with intense complication of decorative detail. Plates LXXXV to LXXXVIII show various aspects of the famous Taj Mahal. Plate XCIII shows the pillar in the centre of the private hall at Fatehpur Sikri, near Agra, on the top of which legend relates that the great Akbar used to sit, while his Hindu, Muhammadan, Christian, Buddhist ministers transacted business in elevated places at the four corners, in sight of their Emperor and connected with him by raised causeways.

Local atmosphere and scenic effects at Kampilong, Peshawar, Amber, Udaipur and on the Jhelum River are well shown in several plates.

The Mount Abu Temples, Plates CXCIX and CCII to CCIV, show an intricacy of design and mastery over material attainable only when consummate patience is joined to a standard of workmanship developed by hereditary employment.

A book to fire the imagination of the most stay at home. R. L. R.

AFRICA

MAREOTIS: being a Short Account of the History and Ancient Monuments of the North-Western Desert of Egypt and of Lake Mareotis. By ANTHONY DE COSSON. *London: Country Life* 1935. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 220 pages; illustrations and maps. 15s*

Mareotis, or the Maryut, is that part of Egypt which stretches west from Alexandria along the Mediterranean coast about as far as long. 29° and southwards towards the Wadi Natrun. Now almost a desert, it was a flourishing country of olives and vineyards from the time of the Old Kingdom until the Graeco-Roman period, when its prosperity was at its height.

The decay of the Maryut began with the Arab invasion; was intensified in the twelfth century owing to the silting up of the Canopic branch of the Nile from which Lake Mareotis, around which the life of the province centred, drew its water; and was completed with the ruin of Alexandria under the Turks.

The first part of this book gives a general account of Mareotis in antiquity; and the second a useful list, with plans and photographs, of the many ancient sites, most of which date from the Graeco-Roman period. There is a chapter describing the efforts of the Egyptian Government, following up the lead given by Major Jennings Bramly at Borg el Arab, to recapture by agricultural development the prosperity of the past.

It is plain that from wide reading and personal exploration Mr. de Cosson has an extensive knowledge of his subject. One feels that he might have presented it more attractively by giving us a connected story in his own words, rather than by so frequent use of verbatim quotations from his authorities. The illustrations are excellent; the sketch-map could have been improved by more attention to lettering and conventional signs. W. B. K. S.

GARDENING IN EAST AFRICA: by Members of the Kenya Horticultural Society and of the Kenya and Uganda Civil Services. Edited by A. J. JEX-BLAKE. *London: Longmans, Green and Co.* 1934. 9×5½ *inches;* xvi+330 *pages; illustrations and sketch-map.* 12*s* 6*d*

It has been truly said that wherever there is an Englishman there is also a garden. The present volume records the experiences in garden-making of the British settlers in East Africa. It provides an impressive record of triumphs over a variety of conditions of considerable difficulty, and should prove of great use to future gardeners not only in East Africa but also in other parts of the world with a similar climate.

The Editor, Dr. Jex-Blake, drives a double team of contributors, composed of officials in the Government Service and members of the Kenya Horticultural Society. Considering this, the various sections receive a surprisingly uniform treatment, though it would have been an improvement if in all chapters the specific as well as the generic names of the plants had been given.

There are twenty chapters, including such general topics as climatic conditions and propagation, as well as more specialized subjects such as vegetables and fruit, insect-pests, and gardening at the coast. The scholarly foreword by Sir Arthur Hill and the six coloured illustrations of native plants add to the attractiveness of a book which should have a ready sale among horticulturists in all parts of the world. J. S. L. G.

LIBYAN SANDS. By RALPH A. BAGNOLD. *London: Hodder and Stoughton* 1935. 9×5½ *inches;* 352 *pages; illustrations and maps.* 15*s*

Readers of the *Geographical Journal* will be already familiar with the scientific results of Major Bagnold's extensive exploratory journeys in the Libyan Desert, since they have been described in papers recently published therein. In 'Libyan Sands' he gives us a connected general account of these and other journeys, in pleasantly written narrative form, with maps which enable the text to be easily followed, and a number of excellent illustrations. The book is eminently readable, and gives a very clear general picture of the regions covered, some of which had not previously been visited by any European traveller. Major Bagnold's enthusiasm for the desert will almost certainly communicate itself to many of his readers who have not yet fallen under its fascination. To such as may contemplate tasting for themselves the joys of desert travel by motor car, Major Bagnold's modest descriptions of how he organized his expeditions, and how he and his companions surmounted the various difficulties that arose during their advance into the unknown, will afford valuable information; while careful attention to the wise words of warning at the end of the book will secure them against risk of disaster if long journeys are to be undertaken. J. B.

NORTH AMERICA

ROUND MYSTERY MOUNTAIN: A Ski Adventure. By Sir NORMAN WATSON, Bt., and EDWARD J. KING. *London: Edward Arnold & Co.* 1935. 9×5½ *inches;* xii+246 *pages; illustrations and sketch-maps.* 15*s*

Far beyond Canadian geographical circles alone it has become known in recent years that the Coast Range of British Columbia composes not merely an extensive forested hill region with occasional snowy summits, but that it contains an immense area of high peaks and glaciers that exceeds anything to be found in the main chain of the Rocky Mountains. Although that area lies within 100 miles of the city of Vancouver it was not till 1927 that two of its citizens, Mr. and Mrs. Don Munday, commenced their notable explorations of what was virtually

virgin country, save for the spasmodic activities on its outskirts of a handful of trappers and prospectors. With what energy and enterprise the Mundays' several expeditions, together with those of Mr. Henry Hall, of Cambridge, Mass., and other members—in particular the Secord-Neave party—of the Alpine Club of Canada, have in the last few years been pursued the pages of the Canadian and the American Alpine journals have borne abundant witness.

In all these explorations the centre of interest has been the culminating point of the range, known officially as Mount Waddington, but widely referred to as "Mystery Mountain," as well as Mount George Dawson, the highest peak of which, triangulated as 13,260 feet, is as yet unascended, in spite of no less than nine attempts to reach it.

It was a chance meeting with Mr. Henry Hall in 1931 in the Rockies that gave Sir Norman Watson his first acquaintance with the Coast Range, for on the spot Mr. Hall invited the latter to join him in an attempt to pioneer an approach to the range from the east. Bad weather prevented much being done, but from a point of vantage some 25 miles away, Sir Norman was so impressed by the magnificent prospect of the long line of dazzling ice-fields and peaks of the Waddington group that he determined to revisit the range at the earliest opportunity. With his background of high Alpine skiing, the idea that mainly appealed to Sir Norman was the attempt to effect during spring a complete crossing of the range on skis from the eastern interior to the waters of the Pacific. By the end of the summer of 1933 the Mundays' and Hall's explorations and attempts on Waddington had shown that a practicable line for such a crossing lay over the range in the vicinity of that mountain, if a notable col known as Fury Gap could be surmounted: Tatla Lake and the upper Homathko Valley would afford a natural, though by no means easy, approach from the east, and the 23-miles-long Franklin Glacier an obviously direct descent to the head of Knight Inlet on the Pacific.

The present volume by Sir Norman and Mr. Edward King, the latter of whom acted in the capacity of transport officer, describes how in the spring of 1934 the plan of crossing the Coast Range on skis was put into effect and successfully carried out, in spite of very considerable difficulties and not a few adventures. The "travellers" of the party were five in number, including Camille Couttet, the young Chamonix guide, and three "packers," with their chief Pete McCormick, constituted an essential link between the outer world and the Scimitar Glacier on the eastern flank of the Range. The narrative gives in considerable detail the great difficulty of forcing a way with pack-horses through heavily forested snow-bound country from Tatla Lake, the trappers' metropolis, to the base camp in the Scimitar Valley. A great tribute is paid to the packers, to their industry and resourcefulness: as the authors say, "this New World breeds a magnificent type." Of them their chief, Pete McCormick, was outstanding, a real relic too of the old hard-bitten pioneers: "as for Pete, that most picturesque old-timer, he is unique. Had he not, with his ready wit, his fertile brain and deep and real knowledge of his mountain country, infused the spark of life and romance into our visit to the Coast Range, these pages would never have been written." Following much "back-packing" (that typical mode of transport so intimately associated with the mountains of Canada) up the Scimitar Glacier, where it was later realized a light sledge would have been a real advantage, on April 14 the first ascent from the east of Fury Gap, 8700 feet, was made by a party led by Couttet. This was of the nature of a reconnaissance and for the purpose of laying a cache of food on the top of the gap for the party that would eventually make the crossing. The attainment of the Gap obviated the necessity for any further search for an alternative pass.

Several days of bad weather, with chinook temperatures, followed, and the party began to despair of effecting the complete crossing of the range. Moreover White, the Canadian skier, had the misfortune to develop a badly swollen knee, the result of a strain aggravated by heavy back-packing. However the weather, such a fickle element in the Coast Range, eventually improved, though unfortunately not White's knee. On April 18 the reduced party consisting of Sir Norman, Wing-Comdr. Beauman, and Couttet determined to set out for the dash to the Pacific across Fury Gap, while the remainder laboriously retraced the route of approach. Couttet's previously cut ice-steps were found to be in a state of good repair, which considering the loads, including skis, that had to be carried and the crossing of a bergschund that had to be effected was a matter of some good fortune. Arrived at the top of the Gap, short respite only could be allowed to contemplate the magnificent scene around, bathed in morning sunshine: it was necessary to push on with the descent down the great Franklin Glacier. On their way on skis over the great névé fields, of almost Arctic proportions, they came within near sight of Mystery Mountain (Mount Waddington), and were duly impressed by its towering ice-plastered precipices, that have so far defied ascent. It is interesting here to note that Couttet considered the climb would be difficult, though, unlike other recently expressed views, not impossible.

But Waddington is not the only unclimbed peak of note in this region, and apart from a climbers' paradise, the party consider the district may eventually become a Mecca for skiers, as the excellent illustrations certainly suggest. Led unerringly by the skilful Couttet, "whose initiative and physical strength were equal to the exacting demands of the Coast Range," the upper icefall of the Franklin Glacier was eventually passed, and at the point of confluence with the Confederation Glacier, some 16 miles from the top of Fury Gap, their small Everest tent was pitched for the night. Next day an 8-mile run under almost flawless skiing conditions, in the early sunshine of a perfect April morning, brought them to the snout of the Franklin Glacier only 8 miles from the Pacific. But their work was not yet done, for many exasperating hours as well as another night, were spent struggling with the dense forest and undergrowth, so characteristic of this Pacific belt of country, before Knight Inlet was reached. There awaiting the tired party, thanks to previous arrangements, was a motor boat, which quickly conveyed them to the local salmon cannery, the only habitation on the inlet. Early next morning a seaplane, summoned by wireless telephone from Vancouver, provided the last episode in the eventful first crossing of the Coast Range of B.C.

The story is well told, and is illustrated with many excellent photographs of what is without doubt one of the wildest and grandest Alpine tracts within the British Empire. Mr. F. S. Smythe contributes an appropriate foreword. It may be added that geologically this region, consisting as it does of one of the greatest known intrusions of igneous rock, has long been considered an area of exceptional interest, and it was more than gratifying that Wing-Comdr. Beauman had the kindness and enterprise under the exacting circumstances to bring back to the writer and an interested colleague some rock-specimens from the heart of the range.

N. E. O.

DEATH ON THE PRAIRIE: The Thirty Years' Struggle for the Western Plains. By PAUL I. WELLMAN. *New York [and London]: The Macmillan Company* 1934. 9×6 *inches;* xii+298 *pages; illustrations.* 12*s* 6*d*

The lurid title and bright colour of the binding of this book must not mislead a prospective reader into imagining that he has obtained a detective story. The

book is an account of the more important episodes in the struggle between the white men and the Indians on the western prairies of the United States during the period 1860–1890. During these thirty years a succession of Indian revolts disturbed the peace of the western settlers. The Indian had been slowly robbed of his hunting grounds by the invasion of the white man and the rapid extermination of the buffalo deprived him of his game. In order to retain the land in its primitive state the Indians kept up an heroic and unequal struggle. "The white man," says Mr. Wellman, "had the repeating rifle, the telegraph, and the railroad. The Indian had only his primitive weapons and his native courage." The struggle between the two races was a fierce one and the cruelties inflicted by the Indians were often equalled by the ferocious atrocities of the whites. The author maintains that the Indians were not always treated with justice in times of peace. "If ever any people was goaded into war," says Mr. Wellman, "it was the Sioux in 1876. And if the World Court of to-day had sat in that period, the United States would have been ruled an 'aggressor nation.' The Sioux war of 1876 was fought because the government could not make its own citizens abide by its treaties." The statistics of the losses of life that occurred in the warfare have been carefully compiled. The book contains some interesting illustrations but no map. E. W. G.

ANNUAL REPORT OF THE DIRECTOR OF THE GEODETIC SURVEY of Canada for the Fiscal Year ending 31 March 1932, pp. 1–30; 1933, pp. 1–20; 1934, pp. 1–15. *Ottawa: J. O. Patenaude* 1932, 1933, 1934

These reports relate to years in which the scope of field work has suffered severe reduction, and themselves show a progressive reduction in bulk. It is the more pleasing to find in them items of considerable interest which show that these lean years are not years of apathy, and that the enforced reduction in field work has been turned to good account, being made an opportunity for several useful inquiries. The vast extent of the Dominion of Canada makes it a splendid field for geodetic operations, and this is further amplified by contiguity with the U.S.A. Thus the survey of the two countries will in many respects make one great whole.

Up to date the Dominion is far from being covered by triangulation and levelling. Indeed there is not yet a continuous primary triangulation from east to west, a gap occurring from 82° to 89° west longitudes. Some 7500 linear miles of first-order triangulation and 1100 miles of second-order triangulation have been actually accomplished. Precision levelling crosses the entire continent and has a mileage of 25,000, to which is to be added 11,000 miles of secondary levelling. But all this levelling and triangulation lies within 500 miles of the southern boundary of the Dominion, leaving the great territories to the north practically untouched.

The great difficulties of transport of personnel have been met in many cases by means of the Royal Canadian Air Force photo-detachment aeroplanes. Aeroplane reconnaissance for triangulation has also been accomplished with success and economy; and the 2600 linear miles already completed suggest that the observational outturn, small during the years covered by these reports, will soon be expanded.

Meanwhile investigations into sources of errors of small precise theodolites have been carried out with important results, of which may be mentioned a modification of theodolite axis design whereby straining of the line of collimation of the telescope has been virtually eliminated, and also the use of a simple prism in front of the eyepiece whereby the image is reversed horizontally and observer's personality of intersection, found to be dependent on brightness of object, may

be cancelled. Two papers by Rannie and Dennis and a third by Rannie deal with these matters. These should be of interest to all concerned with geodetic triangulation and copies may be obtained from the Director, Mr. Noel J. Ogilvie.

There is an interesting note on abnormal vertical refraction in the 1934 report. Such refraction, which on occasion renders stations intervisible for brief periods, depends on abnormally rapid diminution of air density with height—a condition which may be brought about by intrusion of cold air close to the ground or of hot air at a considerable height. The Meteorological Service find it possible to predict the formation of the warm air current twenty-four hours in advance, and so advantage may be taken of it.

Under the heading "Geodetic Research" references are found to an investigation of the best means of converting coordinates expressed on the Clarke spheroid into terms of the International spheroid; and a study of the geoidal form in south-east Canada. The latter has had to be discontinued owing to shortage of data. Such data as exi•ts is in the form of deviation of the vertical and is necessarily limited to regions covered by triangulation. No mention is made of measurement of the *force* of gravity, but it is to be hoped that the Geodetic Survey of Canada will be able to carry through a gravity survey of the Dominion before long. Progress on the instrumental side has recently been rapid and the expectations of the Danish Static Gravity Meter are great; so gravity survey is steadily becoming less formidable. J. DE G. H.

AUSTRALASIA AND PACIFIC

NEW ZEALAND. By W. P. MORRELL. (The Modern World. Edited by the Rt. Hon. H. A. L. FISHER.) *London: Ernest Benn* 1935. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xii + 372 *pages; maps.* 21*s*

This, the latest volume in Ernest Benn's "Modern World" series, is divided into two parts, Part I being entitled "The Growth of the Nation," and Part II "The Life of the Nation." It will be seen that Dr. Morrell, as befits an historian, is primarily concerned with the people rather than with their country. New Zealand being what it is and where it is however a study of the evolution of the nation, if it is to be successful, implies an understanding of the country and its essential geographical conditions. It has indeed been said that the history of New Zealand from the coming of the white man to the Great War was little more than economic history. Constitutional issues did at times take precedence, but the great constitutional questions themselves turned largely on economic conditions, and the economic conditions were rooted in the process of settling an isolated country of strongly marked geographical characteristics. Dr. Morrell is perfectly well aware of all this, and, though he makes no specific study of the geography, a sense of it is implicit throughout his work.

Part I, which comprises six chapters and occupies 114 pages, traces the development of the economy, institutions and "tone" of New Zealand from the earliest discoveries to the present day. The space is short for such a task, yet it has been made adequate. Dr. Morrell's gift of clear and concise writing has enabled him to give a surprising amount of detail without in any way obscuring the main lines of the picture. It is the best short account of New Zealand history known to the reviewer.

Part II forms the major portion of the book. Though informed throughout by the author's historical spirit, and set against the historical background sketched in Part I, it is essentially a critical examination of the present. Farming and other industries, public finance, politics and administration, labour and unemployment, the present-day Maori, cultural life, and New Zealand's imperial and

foreign contacts are all reviewed. Without necessarily agreeing in every detail with the views expressed, one may commend it as a sane and balanced treatment in which the criticisms of certain aspects of New Zealand life are largely justified, and in any case always sympathetic.

The publishers have been scarcely as successful as the author. The reproduction of the maps showing the distribution of sheep and dairy cows leaves a good deal to be desired, and the price of the book seems somewhat heavy. R. O. B.

POLAR REGIONS

SVALBARDBOKEN. By ODD ARNESEN. *Oslo: Nasjonalforlaget* 1935. 7½×5 *inches;* 168 *pages; illustrations and maps. Kr.*5.75

Some account of Spitsbergen figures in most guide books to Norway, but often the facts are out of date and the information is rarely accurate. Mr. O. Arnesen, who has flown in Spitsbergen as well as in East Greenland, has produced a discursive little handbook which certainly does not exhaust Spitsbergen but gives an excellent view of many sides of its activities. He begins with a catechism of the group: in question and answer he provides salient facts of size, topography, climate, resources, and government. Then he deals with the tourist traffic, flying expeditions, timber, coal mines, and so forth, and embellishes the text with a number of fine illustrations and a few sketch-maps. Norwegian interests are very much to the fore, but Sir Martin Conway is given the credit of first exploring the interior, and Andrée, his adventures and final disaster, loom large. Perhaps to those who knew Spitsbergen in past years the chief interest in the country to-day is the importance of Russian mining interests at Coles Bay and at the former Dutch mine at Green Harbour. At both places there are large settlements, and of Spitsbergen's winter population last year of 2416 no less than 1821 were Russians. Russian mines exported 177,000 tons of coal and Norwegian 300,000. The Store Norske Kulkomhagni of Longyear City has now bought the derelict Swedish mine in Braganza Bay. Another matter of interest is the successful introduction of the musk-ox and the Greenland hare, both of which are protected. We note with interest that the Svalbard budget, wholly distinct from that of Norway, balances with a surplus. R. N. R. B

GENERAL

GEORGE FORREST: Explorer and Botanist. Edited by R. E. COOPER, A. O. CURLE, and W. S. FAIR. *Edinburgh: The Scottish Rock Garden Club* 1935. 9×6½ *inches;* 90 *pages; illustrations.* 4*s* 6*d*

Of all the plant collectors who, during the last forty years, have so enriched our gardens, George Forrest, both in the volume and the quality of his introductions, must be considered *facile princeps*. There is hardly a horticultural genus to which he did not add some new and beautiful member from the mountains of China, while his purely botanical work increased immeasurably our knowledge of the flora of that region.

It is fitting that this memorial of Forrest's life and work should have been prepared at Edinburgh, where he did his first botanical work under Professor Bayley Balfour and with which he was so intimately associated for the remainder of his life. The Scottish Rock Garden Club are to be congratulated on bringing out this volume, which will prove of great interest not only to horticulturists in whose gardens Forrest's treasures remain as a monument to his labours but also to lovers of travel and adventure who will find in the record of his hardships and dangers a tale after their own heart.

The volume opens with an account of Forrest's early life, followed by a summary of his expeditions, which extended from 1904 to his death in Yunnan in 1932. Incidents of particular interest are then described in Forrest's own words, reprinted from articles in *The Gardeners' Chronicle* and *The Geographical Journal*. These chapters give a most vivid description of thrilling encounters with hostile natives, during which Forrest nearly lost his life. The crisp prose in which they are written contrasts very favourably with the almost journalistic style of the early part of the book, when the authors have unfortunately sometimes let their enthusiasm run away with their pen. It is to be regretted that Forrest did not live long enough to publish the projected account of his life's work in book form, as it would undoubtedly have been a classic of travel literature.

The book closes with notes on the more important Forrestian introductions, and on the plants of north-west Yunnan, followed by a bibliography. It is profusely illustrated by photographs of plants in their native habitats and of incidents during Forrest's expeditions.

The make-up of the volume is unusual and hardly worthy of its subject. There is no proper title-page and it will be a puzzle for bibliographers to decide how it should be cited. The paper is poor and the pages, with their narrow upper margins, are not pleasant to read. The botanical names are however commendably free from misprints. J. S. L. G.

GLI STATI DEL MONDO. Commento geografico-statistico all'atlante internazionale del Touring Club Italiano. *Milano: Touring Club Italiano* 1934. 9×12 *inches;* 1287 *pages; maps and diagrams. L.*70

This is a most ambitious work of reference, purporting to be a complete encyclopaedia of knowledge concerning all the countries of the world. It is fairly detailed in its information, though the statistics it gives must inevitably be out of date before it appeared. The main physical features of every country are described, the population and its distribution, the political machinery (again out of date in several cases). It is in many cases impossible to test the accuracy of the statistics, or even of the factual information; but if the standard of accuracy achieved in the article on Great Britain is maintained throughout the whole work, 'Gli Stati del Mondo' is a valuable work of reference of a fairly general kind. In the section dealing with Great Britain, for instance, tarns are described as semi-circular lakes, but otherwise the information seems to be accurate. The book is well provided with small maps and diagrams. M. C.

THE ATLANTIC AND SLAVERY. By the Hon. H. A. WYNDHAM. (Problems of Imperial Trusteeship.) *London: Oxford University Press* (*issued under the auspices of the Royal Institute of International Affairs*) 1935. $8\frac{1}{2}\times5\frac{1}{2}$ *inches;* viii+310 *pages; maps.* 12*s* 6*d*

This volume is one of a series called "Problems of Imperial Trusteeship," which began in 1933 with a comparative study of native education. It attempts a comprehensive study of certain aspects of the relations between Europeans, Negroes, and American Indians (of North, South, and Central America, on the eastern and western shores of the Atlantic). And it professes to cover the period from the earliest European settlements in America down to the end of the eighteenth century.

In preparing this volume, Mr. Wyndham has had help from a number of scholars, publicists, and other workers. As from Mr. C. C. Ross, on certain legal aspects of slavery; from Dr. Charles W. Buckby and Miss Jean Garlick, on the British West Indies; and from Dr. L. P. Mair, who has conducted

researches in the colonial archives in Paris. The map of the kingdom of Congo, on p. 95, which is perhaps of especial interest, is adapted from one by the Jesuit Father J. van Wing, in 'Études Bakongo.'

Like Caesar's Gaul, the book is divided into three parts. In the first, given to the West Coast of Africa, the Gold Coast and Slave Coast of Guinea are especially treated, and the kingdom of Kongo and Angola. The successive activities of Portuguese, Dutch, Brandenburgers, and British are traced on the Guinea Coast.

Next we have the east coast of America, and especially the Spanish system in Mexico; the Portuguese system in Brazil; the missionary experiments, and especially the Jesuit Reductions in Paraguay; and the British system in the more southern American colonies of the north (Virginia, Maryland, the Carolinas, and Georgia).

Finally we have the subject of slavery (which has already run through a great deal of this volume) treated in several sections. As, for example, Negro slavery proper; the attitude of some European thinkers, legists, and pioneers towards slavery; slavery in Mexico, Brazil, various West Indian islands, and North America.

The author describes his treatment as being a history of part of the great migration from the east to the west coasts of the Atlantic, which was one of the most pregnant movements generated in the Age of Discovery, recasting the population of a continent, and converting it into one of the richest in the world.

The movements described may be considered as movements of men from east to west: of products from west to east. Thus parts of this book are devoted to the recessive contracts on the west coast of Africa, and parts to penetrative contacts on the east coast of America.

The present work claims to cover the period from the beginning of the great Age of Maritime Discovery in the fifteenth century down to the Age of the French Revolution. It emphasizes the real independence of most of the native states and tribes behind the African coast itself, in reference to the Europeans, who so rarely attempted, except in regions like Kongo, any deep penetration, or effective domination, of the interior (in all this contrasting strikingly and interestingly with the Age of African Partition by European Powers, fully developed from 1883, and somewhat in evidence long before that). "As . . . the slave trade grew in importance, it became recognized . . . that the sovereignty of the Africans was unimpaired by the presence of the Europeans. . . . Activities other than trading . . . were deprecated," because "the land occupied by the Europeans was only leased from the natives." Thus commercial success on these coasts naturally depended on the goodwill of the chiefs. And examples are given of the methods, sometimes amusing and often rather undignified, by which Europeans of the seventeenth and eighteenth centuries endeavoured to secure that goodwill. Naturally Mr. Wyndham emphasizes the abstentionist attitude of the Europeans, who are simply traders and aspire to nothing but commerce, and who permit their operations everywhere to be hampered by African idiosyncrasies, customs, and exactions.

To the present reviewer, by far the most readable and attractive portions of this volume are the chapters which deal with the Portuguese experiment in Kongo (so largely a Christian missionary enterprise) and the Jesuit missions and theocracies in parts of South America. A good deal of the volume can hardly be considered an example of very fascinating treatment in history. Some of it indeed seemed to us pretty heavy reading. Yet a great deal of useful material is here presented. R. B.

THE MONTHLY RECORD

THE NEW SECTION OF THE ALBERT CANAL

The construction of the new section of the Albert Canal between Antwerp and Herenthals is a great feat of engineering. *The Times* of May 14, in which the opening ceremony is reported, refers to the Albert Canal as a whole as "one of the greatest engineering feats in the world." The South Willemsvaart Canal, on the left bank of the Meuse, had been constructed by the Dutch in 1826, and after the separation of Belgium and Holland the Belgians made a series of canals joining the Scheldt at Antwerp to the South Willemsvaart Canal below Maastricht, where the canal passes through Belgium. Recently however the river traffic of the Meuse has increased enormously, and round Maastricht serious delays were caused by the numerous movable bridges, three locks with out-of-date equipment, and the various Customs complications. In 1925 the Dutch constructed the Juliana Canal on the right bank of the Meuse, joining Maastricht to Maasbracht. This canal was entirely in Holland: and Belgian engineers, not to be outdone, then drew up a similar plan for the construction of an all-Belgian canal. The Albert Canal joins the Meuse at Visé, and then, emerging into the valley of Geer, where it curves to keep the line of the frontier, and passing along the sides of the hill of Vroenhoven, it turns west. Here the engineers met their greatest difficulty—the construction of a cutting 100 feet deep and nearly 2 miles long into a bed of very fine sand impregnated with water. This difficulty has been successfully overcome, and Belgium can now boast a canal which will not only be of great economic benefit to the country, but will also serve as a superb military line of defence in case of invasion.

NEW GERMAN PUBLICATION

We have received from the publishers, with a request for a notice in the *Journal*, the first eight parts of a new reference work entitled 'Handwörterbuch des Grenz- und Ausland-Deutschtums' (Breslau: F. Hirth 1935). The design of the work is clearly indicated by the title, and examination of these parts shows that it has been carried out consistently. The areas of German settlement along or near the present boundaries in Europe naturally receive most attention, but the relations of Germany with all the countries of the world and the share of Germans in their exploration and development are described in detail, and general subjects are also dealt with. Thus the volume opens with a ten-page article on Aachen, illustrated with sketch-maps: this is followed by a short article on Abyssinia, over half of which is devoted to German travellers and relations with Germany. An idea of the scope of the work will be apparent from a list of the lengthier articles, ranging from thirty to seventy-five pages, already published: they include the Banat, Batschka (Hungary), population problems, agricultural system (including the treatment of settlement forms), Australia, Bessarabia, and Brazil. Many of these articles are illustrated by sketch-maps, and there is one folding map. Wherever possible, the treatment is geographical: authorities are given for the statistics quoted, and short bibliographical references mainly but not exclusively to German works.

A close examination of the section on Australia makes clear the merits and shortcomings of the work. The factual accuracy is high, and the documentation, including references to unfamiliar German sources, is full. It is the only easily accessible review of the life of Germans in Australia, and is a useful summary of Australian economic geography from an unusual angle. On the other hand, an effect of distortion has been produced, not by misrepresentation but by

emphasis and exclusion. Everything that can be claimed as indicating German influence is set down, even to place-names commemorating Prince Albert and Queen Adelaide. The absence of any standard of comparison of necessity causes the German contribution to Australian life to appear very great, and in places the impression is given that the material has been skilfully employed to foster this impression. Despite this attitude however the history of German settlement in Australia is tinged with regret that "Deutschtum" has failed to establish itself. If employed with discretion therefore the completed work should be useful to students.

SEASONAL MOVEMENTS OF SHEEP IN WALES

In an article entitled "Seasonal Movements of Sheep in Wales" published in the *Quarterly Journal of the Manchester Geographical Society* (vol. xlv. 1934–35) Mr. Elwyn Davies gives an account of a modified form of transhumance which has been in vogue for many centuries in Wales. Configuration and climate make Wales, in the main, a pastoral country, there being little arable cultivation above the altitude of 600 feet. The upland farms, which are situated chiefly between 600 and 1000 feet above sea-level, have a mixed pastoral economy, growing oats, barley, hay, and root crops, and breeding sheep and cattle. Beyond the upper limits of the enclosed fields extend the unenclosed moorland pastures over which the higher farms usually possess grazing rights. The general mildness of temperature permits a number of the more hardy sheep to be kept out of doors throughout the year, so that the upland farmer makes sheep-husbandry the pivot of his economy. Large flocks are consequently grazed on the upland sheep-walks.

But the onset of winter conditions in November makes matters on the high moors difficult. Large areas are under snow for long periods, vicissitudes of temperature are great, the rainfall is heavy, and the impervious, badly drained character of the plateau surface causes extensive bogs. Moreover some of the flora, including *Nardus* and *Molinia coerulea*, is seasonal in character affording keep only during late spring and early summer. Thus the upland pastures possess a seasonally very diverse stock-carrying capacity, being able to support more than twice the number of sheep in summer as in winter. The upland farmer, unable to accommodate all his sheep on his lower-lying enclosed farmland, sends a large part of the flock to spend the winter at lower levels. These sheep go to lower hill-farms which have an economy based on the rearing of store cattle and on dairying. On these farms most of the cattle are kept inside during the winter, leaving the fields free for the migrating sheep.

In Wales the movement of mountain sheep on an extensive scale to lower levels in autumn and the return in spring depends on the close juxtaposition of upland and lowland. The contrast with Scotland in this respect is great, for there lowland areas are extensive only around the periphery of the highlands, and the distances are too great to make seasonal transference of flocks practicable.

Formerly the flocks used to travel at leisure along the mountain paths and roads in charge of the shepherds, but it is now more usual to send them by train or motor lorry. The extent and dates of the movements naturally vary with locality. It is always to the lower hilly slopes between 200 and 900 feet that the sheep are sent, not to the rich valley bottoms which would render them unfit to return to the highlands. Sketch-maps accompanying the paper indicate the lines of movement separately for North and South Wales.

Farmers in the Snowdon region use three wintering areas, the Clynnog district near Carnarvon, the Eifionydd lowland near Criccieth, and the eastern slopes of the Conway valley. In the high Berwyn Range migration is never very

far, the sheep wintering on the adjoining lowland slopes. From Plynlimmon, the Mynydd Bach, and even as far away to the east as the Mynydd Epynt, sheep descend to the coastal plateau of Cardiganshire, and from the Black Mountains and Brecknock Beacons to the lowlands of Monmouthshire. The farms on the slopes of the lower moorlands of Denbighshire generally possess sufficient land to accommodate their sheep throughout the winter, but in some cases sheep are sent as far afield as the upper Dee Valley. In Pembrokeshire, which has a milder climate and comparatively little high land, no migrations to winter pastures take place.

THE MAP OF WALES

We have received from the Director of the National Museum of Wales a publication by Dr. F. J. North outlining the history of the map of Wales before 1600 (first printed in *Archaeologia Cambrensis*, 90 (1935)). Such a sketch must, in the earlier centuries at least, of necessity be concerned with general cartographical history rather than with the mapping of Wales, but the author has skilfully maintained a balance, and concentrated the interest on his special area. The development of the map of Wales, as might be expected, has advanced parallel with that of England. Dr. North clearly shows that the important stages are marked by the "Gough" map, the Mercator map of 1564, Humphrey Lhuyd's maps, and Saxton's map of 1579—the Mercator being the first to show a coast-line approximating to reality, while Saxton displayed a remarkable acquaintance with the hydrographical system. The Lily map of 1546 does not perhaps show so marked an advance in its treatment of Wales as in other areas: the author believes that it has associations with the anonymous British Museum map of 1534, though Mr. Edward Lynam has come to the opposite conclusion. Dr. North has devoted considerable attention to the place-names found on these early maps, especially on the portulans, and in sailing directions. Owing to the frequent displacement of names, and the careless manner in which they were copied, this is a difficult task, and it is to be hoped that he will be able to complete his investigations. The evidence for Leland's influence upon the nomenclature of the sixteenth-century maps is strengthened by this monograph. The pamphlet is illustrated by several reproductions and a number of clear diagrams.

HOUSE TYPES IN OCEANIA

To the series "Studien zur Völkerkunde" Dr. H. Tischner has contributed a monograph upon the distribution of house-types in Oceania. The material for the study has been collected from the available literature and ethnological museums in Germany. He has studied the house from the point of view of construction and of the uses to which it is put, and his results are summarized in nine sketch-maps upon which the various groups are shown in colour. The various distributions do not separate out very distinctly, except perhaps the tree-dwellings. Permanent dwellings in trees are found only in North-west New Guinea, though they are used as refuges in various parts of that island, in neighbouring groups of Melanesia, and in the north island of New Zealand. The distribution of the dwelling-house on piles corresponds fairly closely to this, except for New Zealand, where they are used as provision stores. This distribution cannot be explained by reference to the topographical environment. The allocation of houses for the use of the men is general, as, with the exception of New Guinea, is the distribution of "boat houses." As the accounts of travellers, especially the earlier, are not always reliable, and the evidence for the present day is not complete, the author has refrained from attempting to sketch the courses of cultural movements.

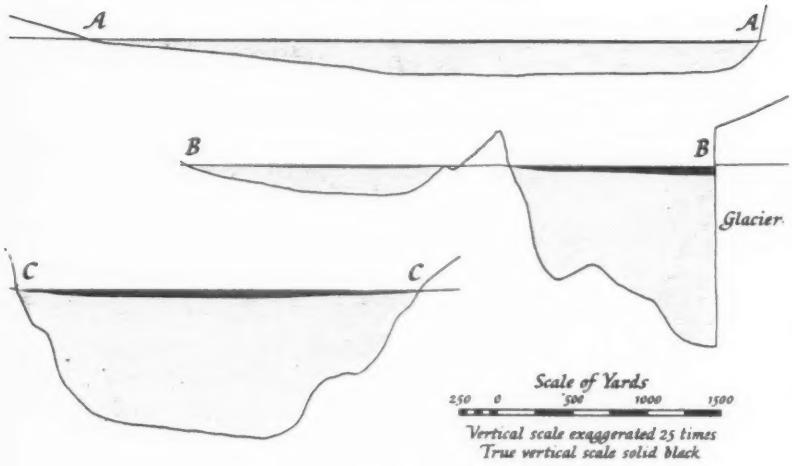
LAKE OF GENEVA CIRCULATION

From time to time disputes, sometimes violent, have occurred between fishers on the French and Swiss shores of the Lake of Geneva concerning the alleged drift of nets from one side to the other, and in 1926 it was decided by the Swiss and French Governments to institute an investigation. The results are described by Professor P. L. Mercanton of Lausanne in a Report entitled "Étude de la Circulation des Eaux du Lac Leman," published in the *Mémoires de la Société Vaudoise des Sciences Naturelles*, vol. 4, No. 4, 1932. The primary object of the research was to answer the practical question whether fishing nets cast into the coastal waters can, during the ordinary time of immersion, traverse the great lake from one side to the other; but it was also hoped to study the general system of circulation about which little is known.

The practical conclusions are summarized as follows: Nets immersed at the usual distance from the Swiss shore between Ouchy and Vevey and left to themselves for the normal period, show little tendency to drift from Swiss waters into French. In the majority of cases their drift is slow and alongshore, not across the lake. The transverse component of the drift is however outward rather than shoreward. Whenever the currents do carry a net into foreign waters it is always after an interval greatly exceeding that usual to fishermen. These results are confirmed for the French Government by M. Kreitmann, who adds in a note that the chances of loss of nets in this manner under ordinary circumstances are practically nil.

It was realized by both parties to the investigation that the circulation of the waters of the Lake of Geneva presents a very complex problem which can only be solved by recourse to all the resources of oceanographic exploration. In consequence of the vast extent of the lake, its changing depths, the relief of its shores, and the conflicting winds that commonly agitate its surface, there is a marked tendency for a system of juxtaposed vortices to be set up. These eddies, seen from the air, stand out as dark patches against the general blue of the water, and their aspect recalls the astronomical photographs of spiral nebulae.

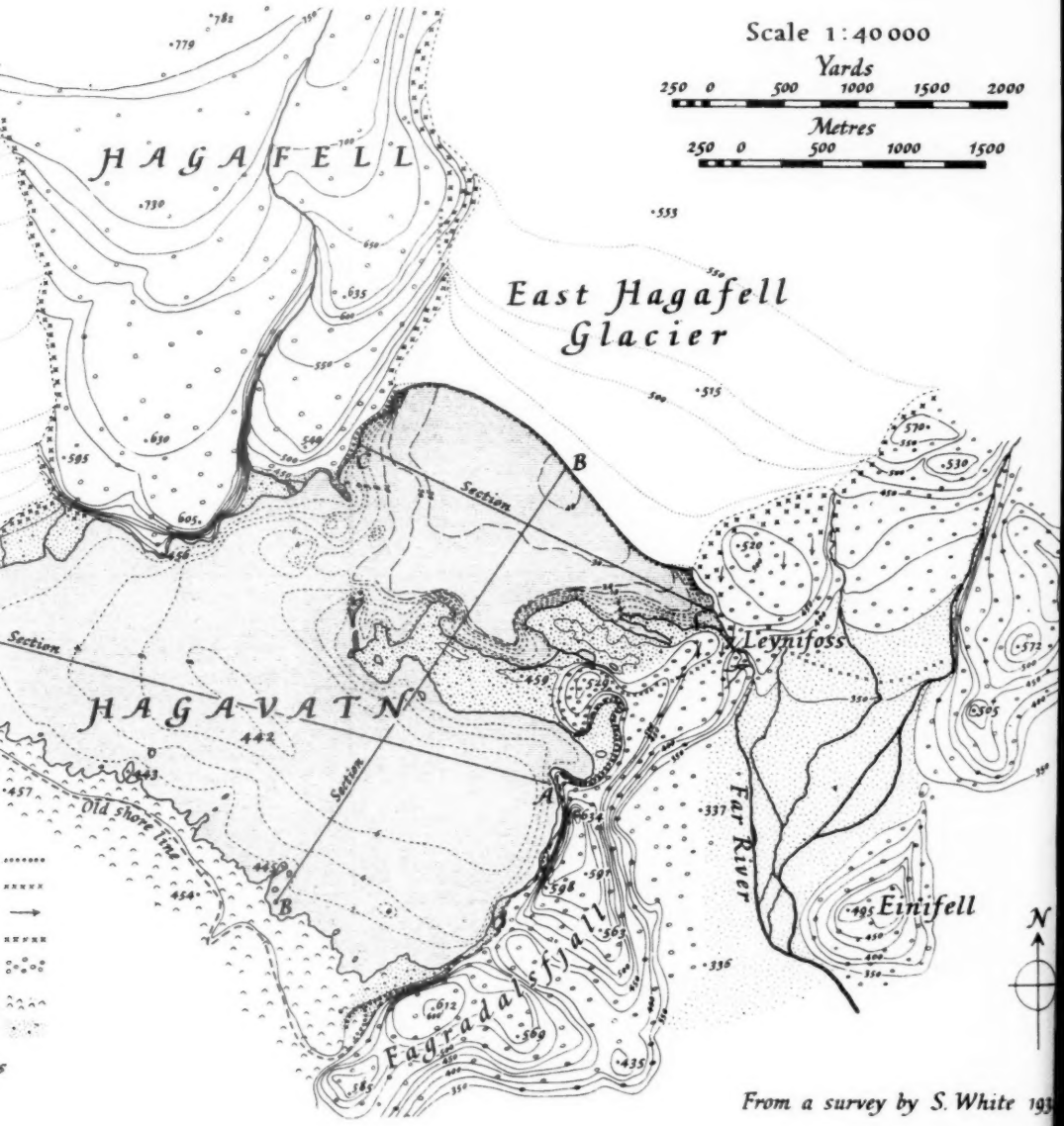
Sections of Hagavatn



No. 1

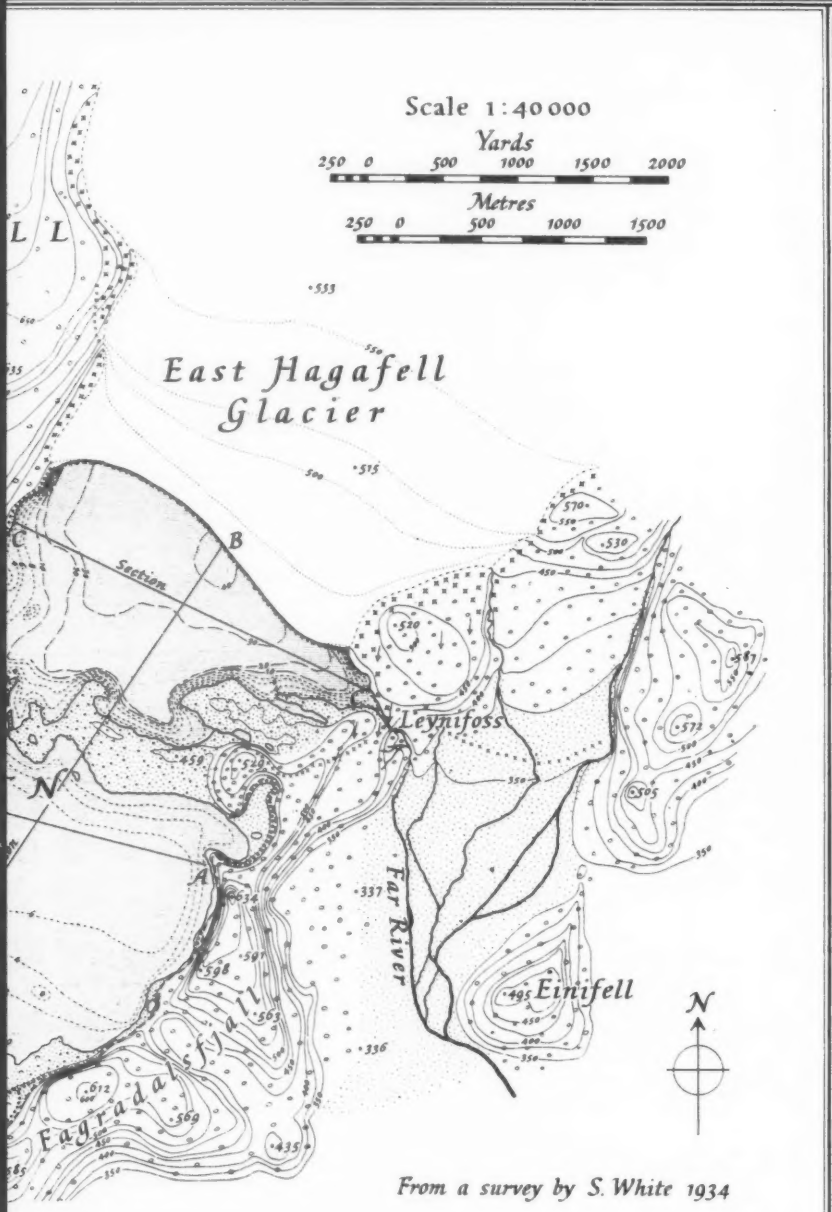
Raised beach .....
"Young" moraine ▪▪▪▪▪
Glacial striae →
Moraine ▪▪▪▪▪
Tertiary volcanics (tuff, lava etc.)
Recent lava
Water sorted material (sands, gravels etc.)

Heights in metres



From a survey by S. White 193

Maps of the Cambridge Expedition to HAGAVA



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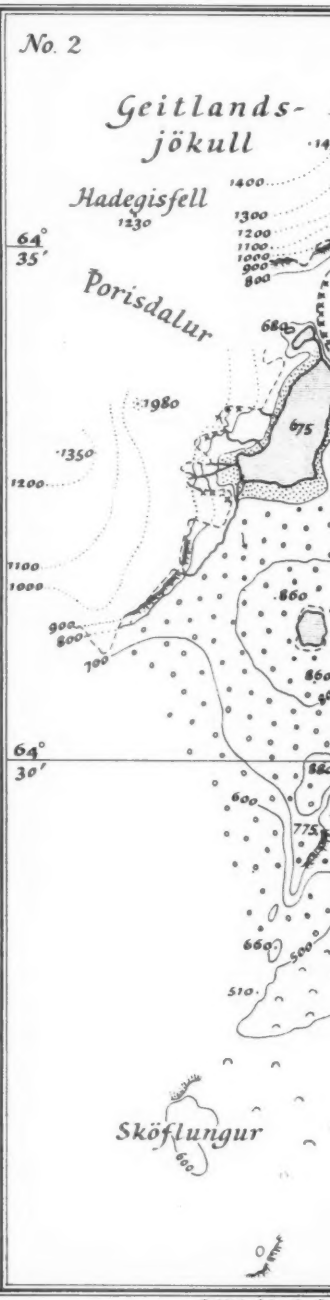

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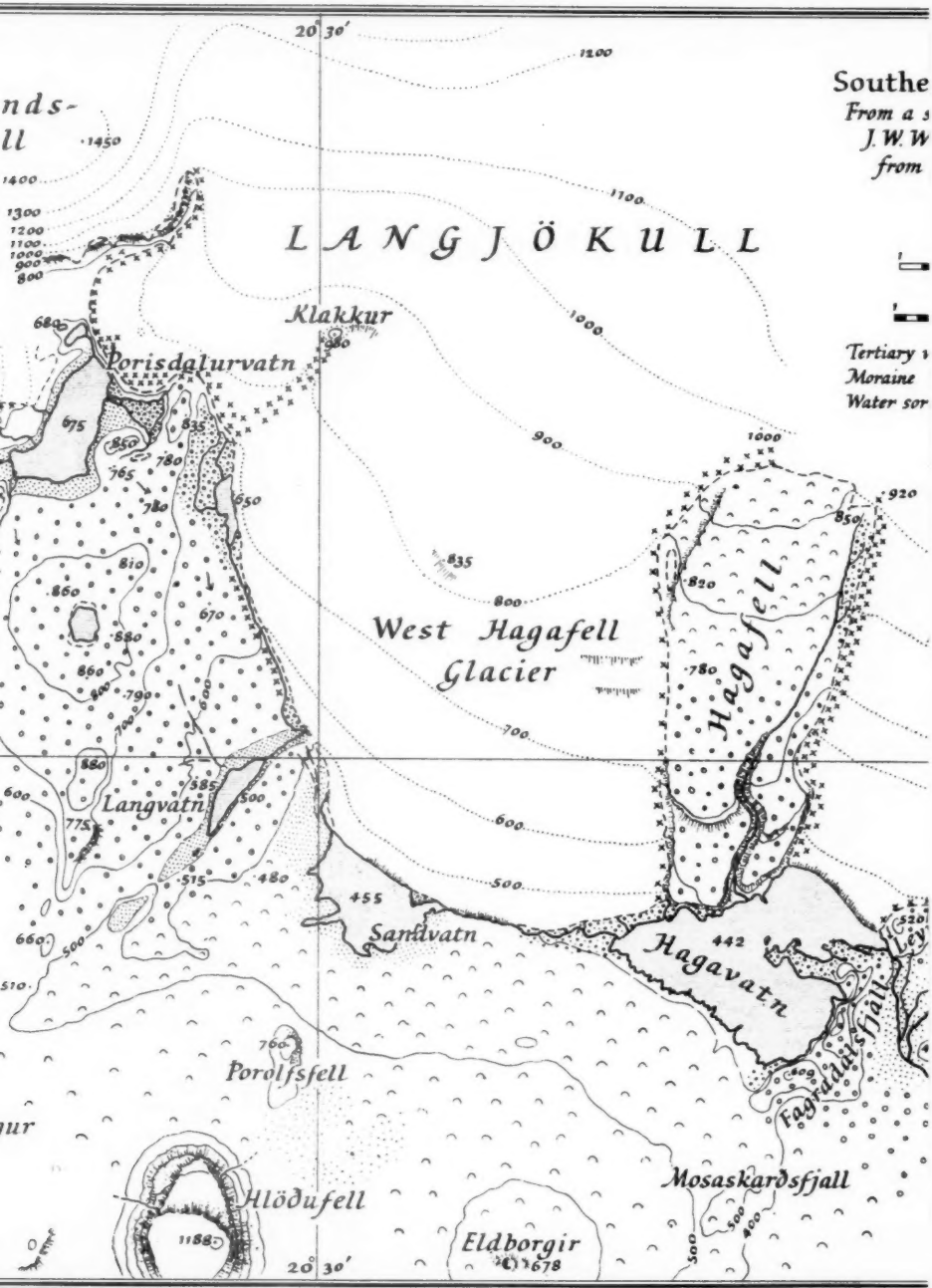
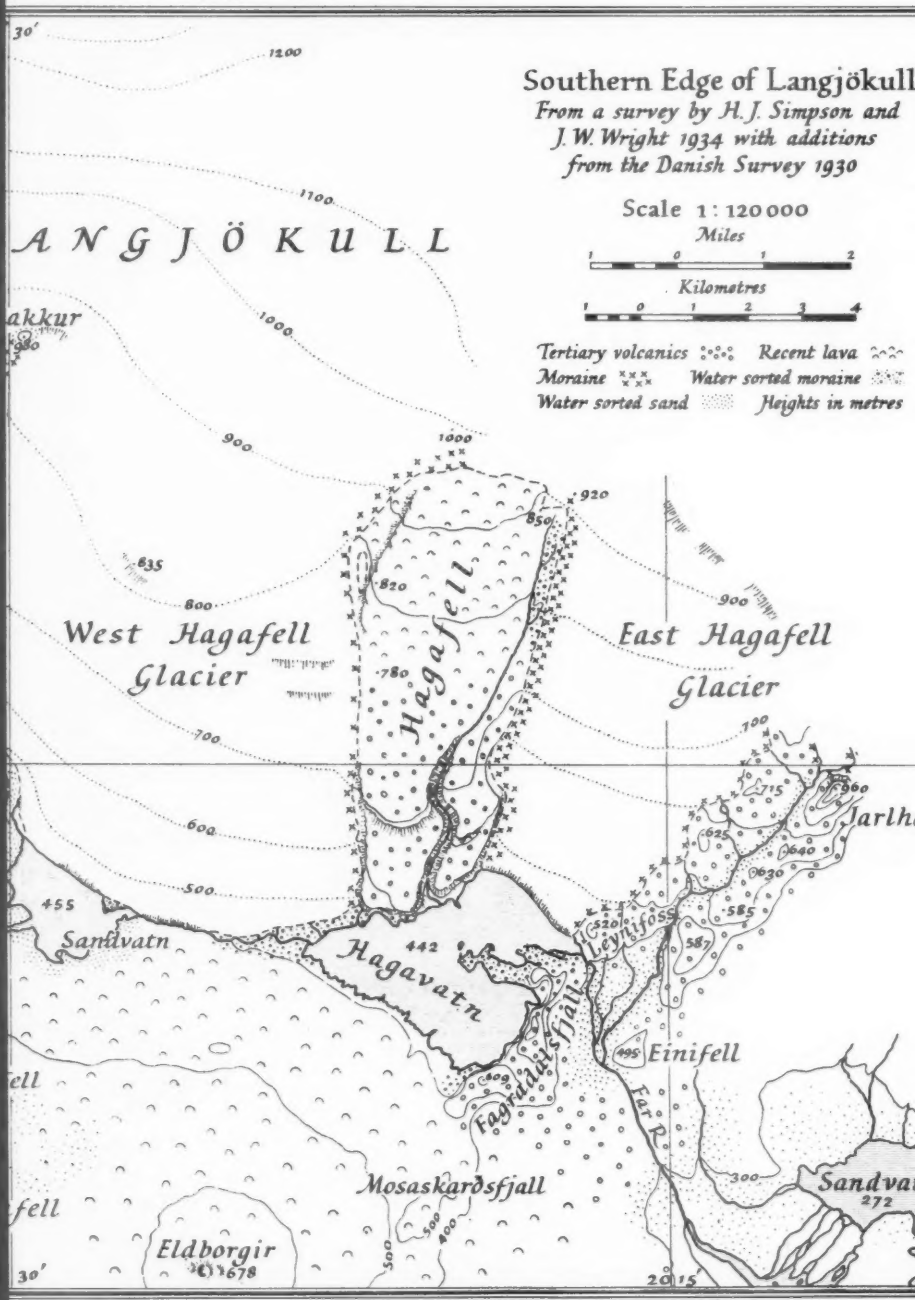
CELAND

GAVATN 1934 to accompany the paper by J. W. Wright



ished by the Royal Geographical Society

company the paper by J. W. Wright



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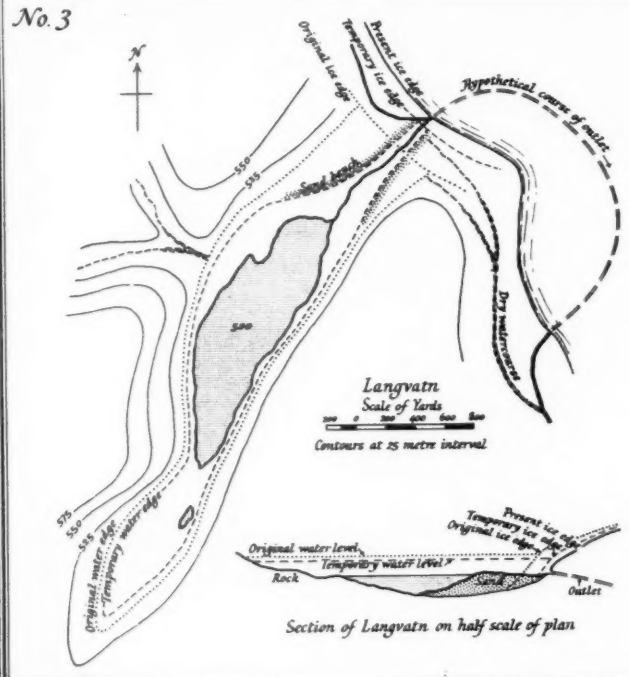

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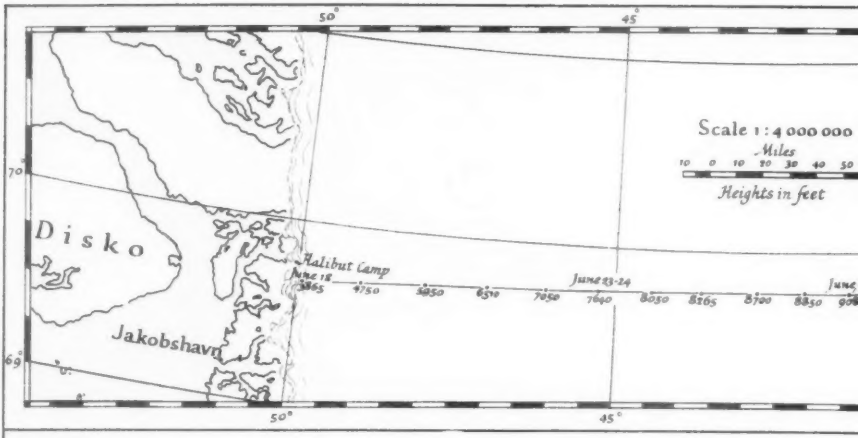
HAGAVATN GORGE
Wright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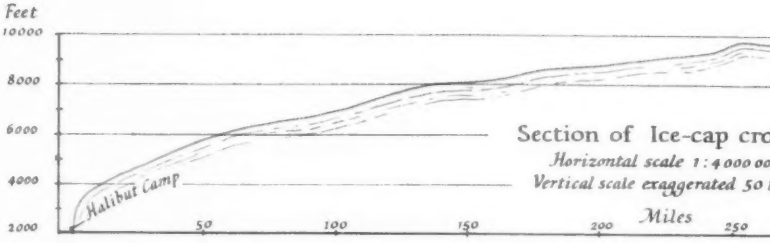
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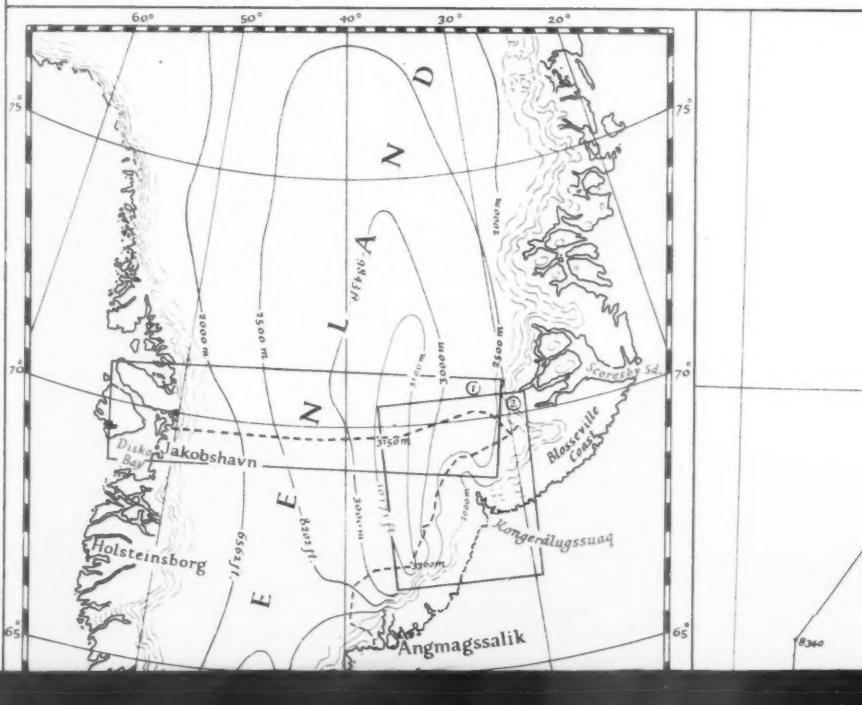
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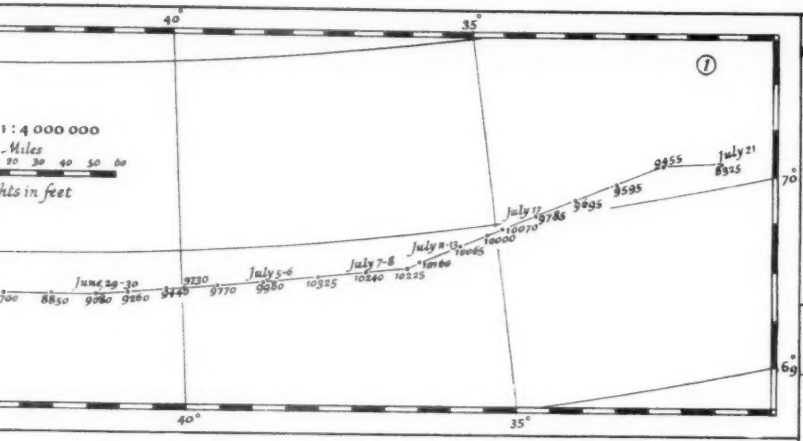
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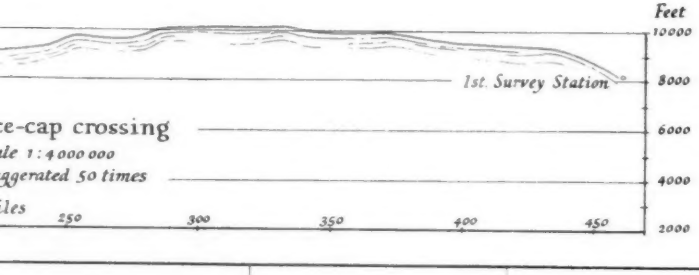
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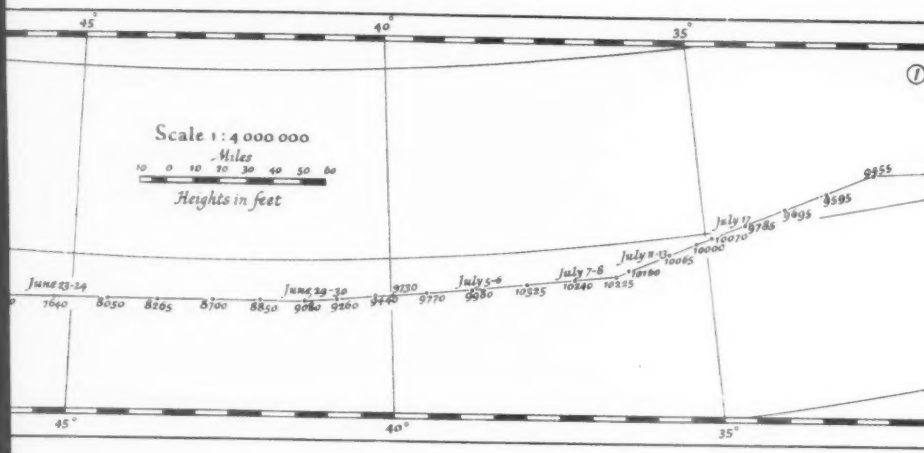
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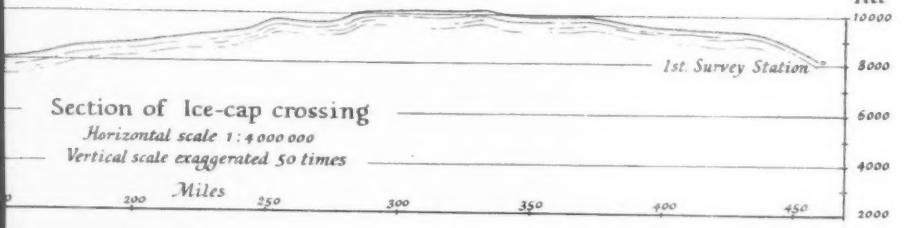
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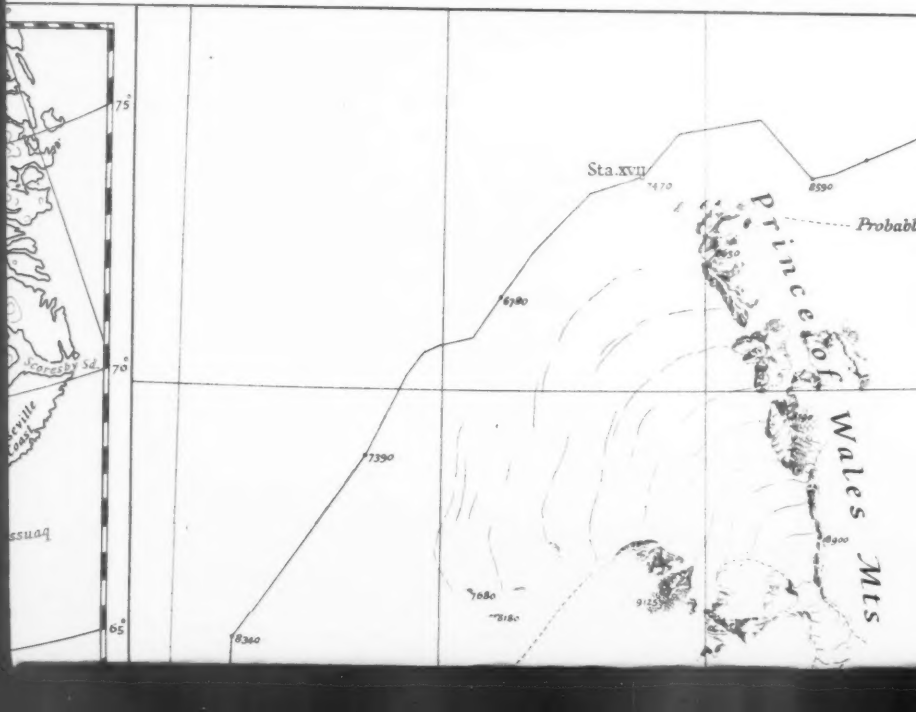
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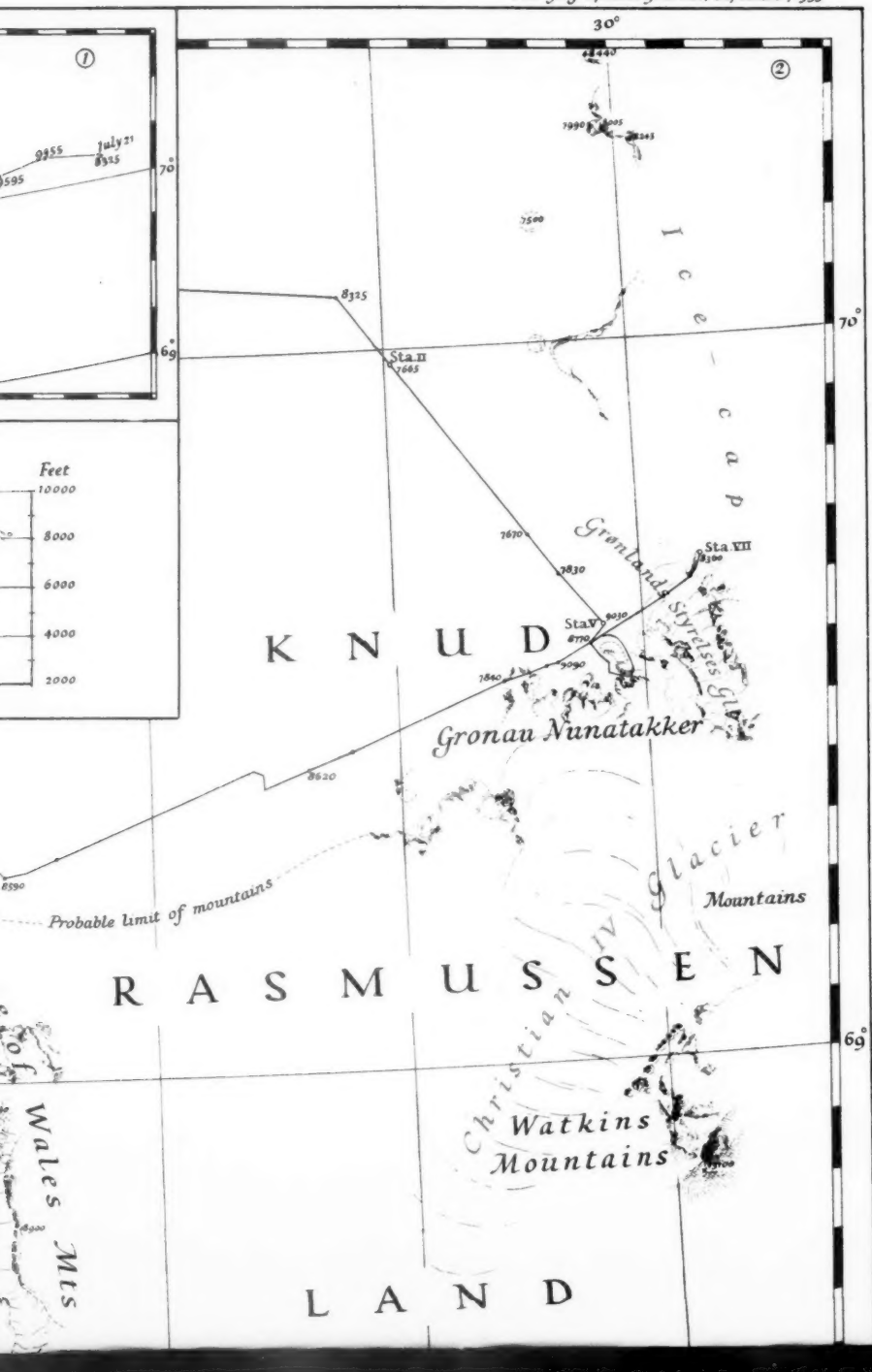
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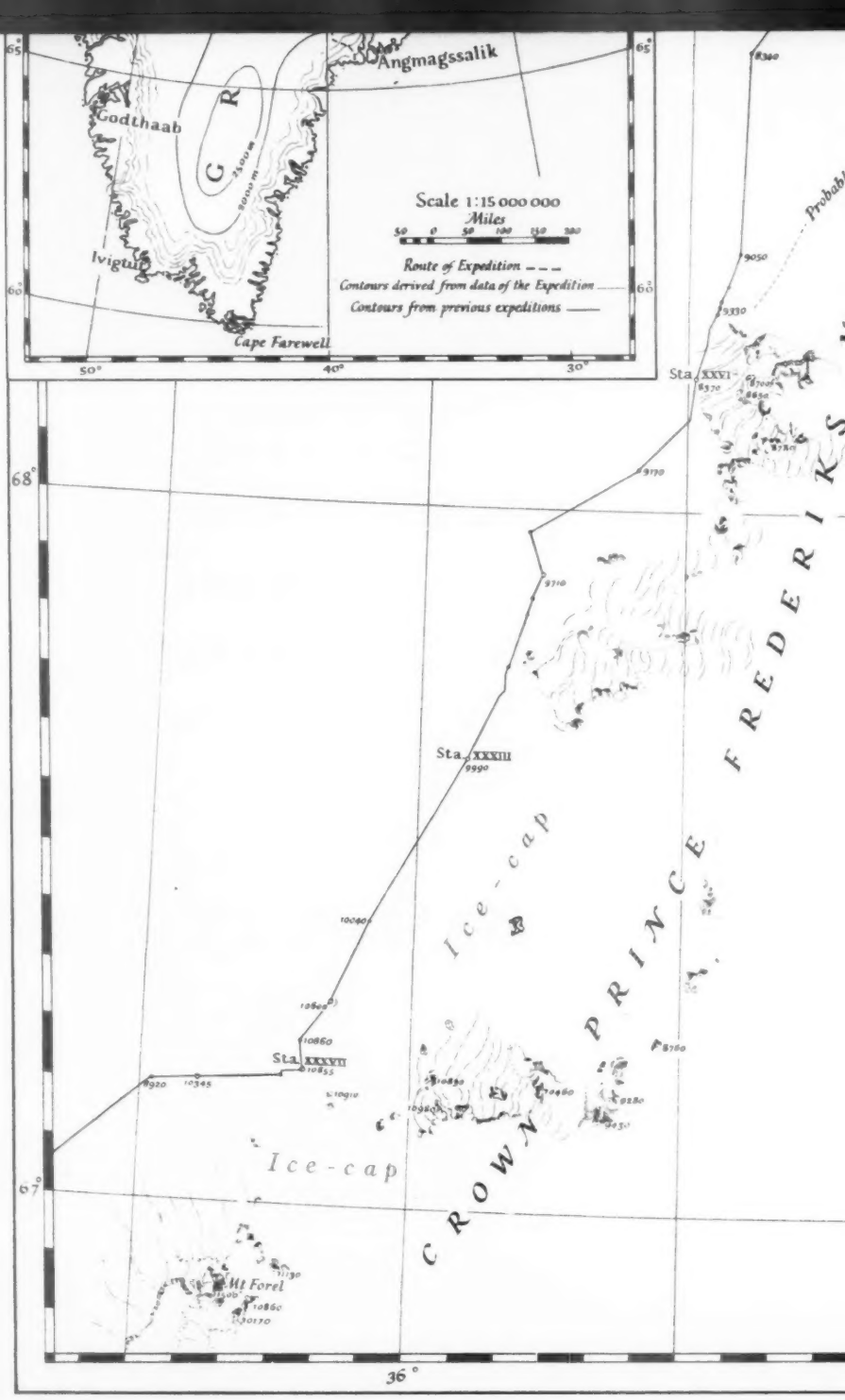
Angmagssalik
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Route of Expedition
Contours derived from data of the Expedition
Contours from previous expeditions
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Ice-cap
Ice-cap
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THE BRITISH TRA
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Map showing the route and
from a survey by Lieu

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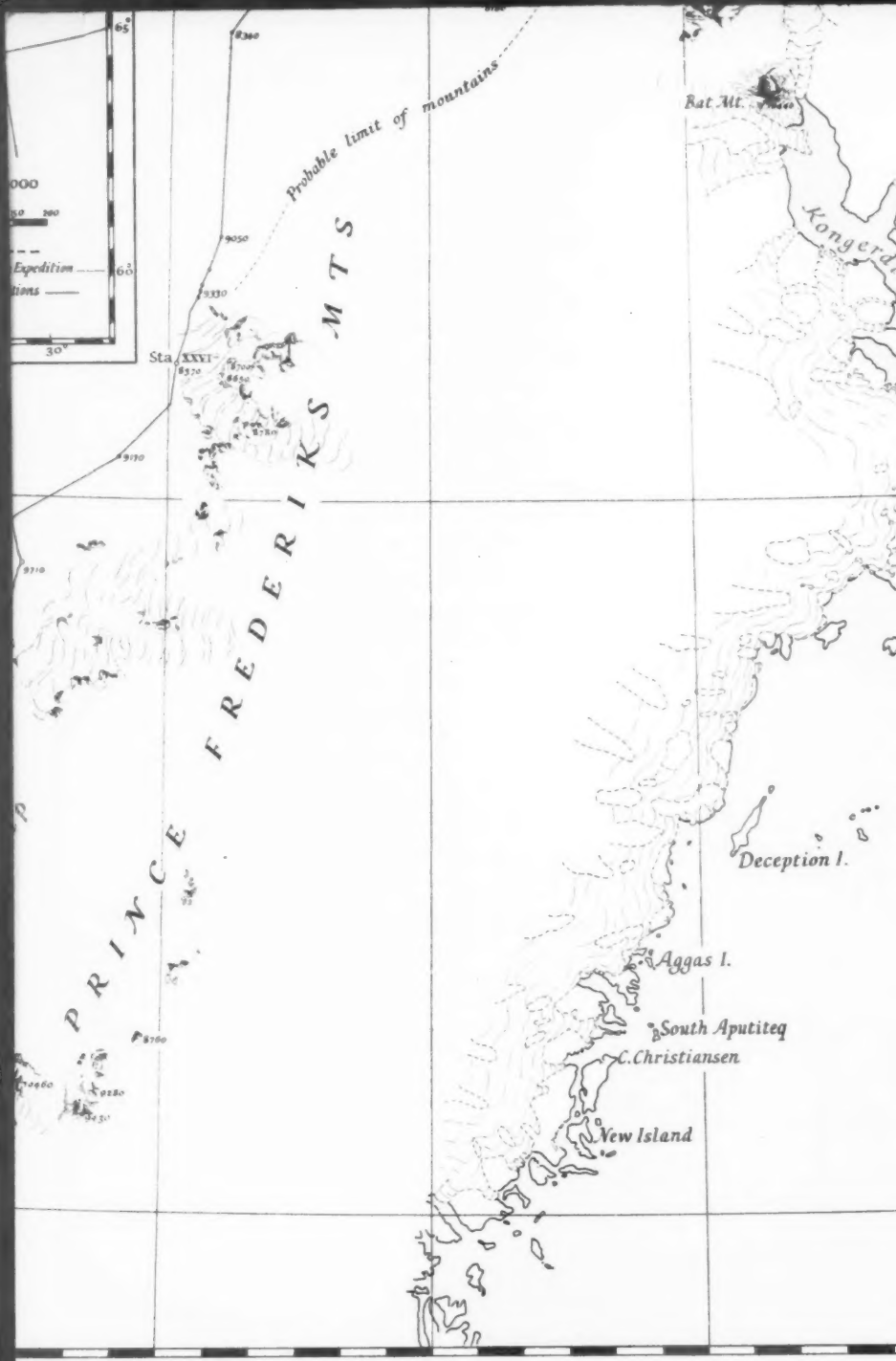
Published by the Royal Geographical Society



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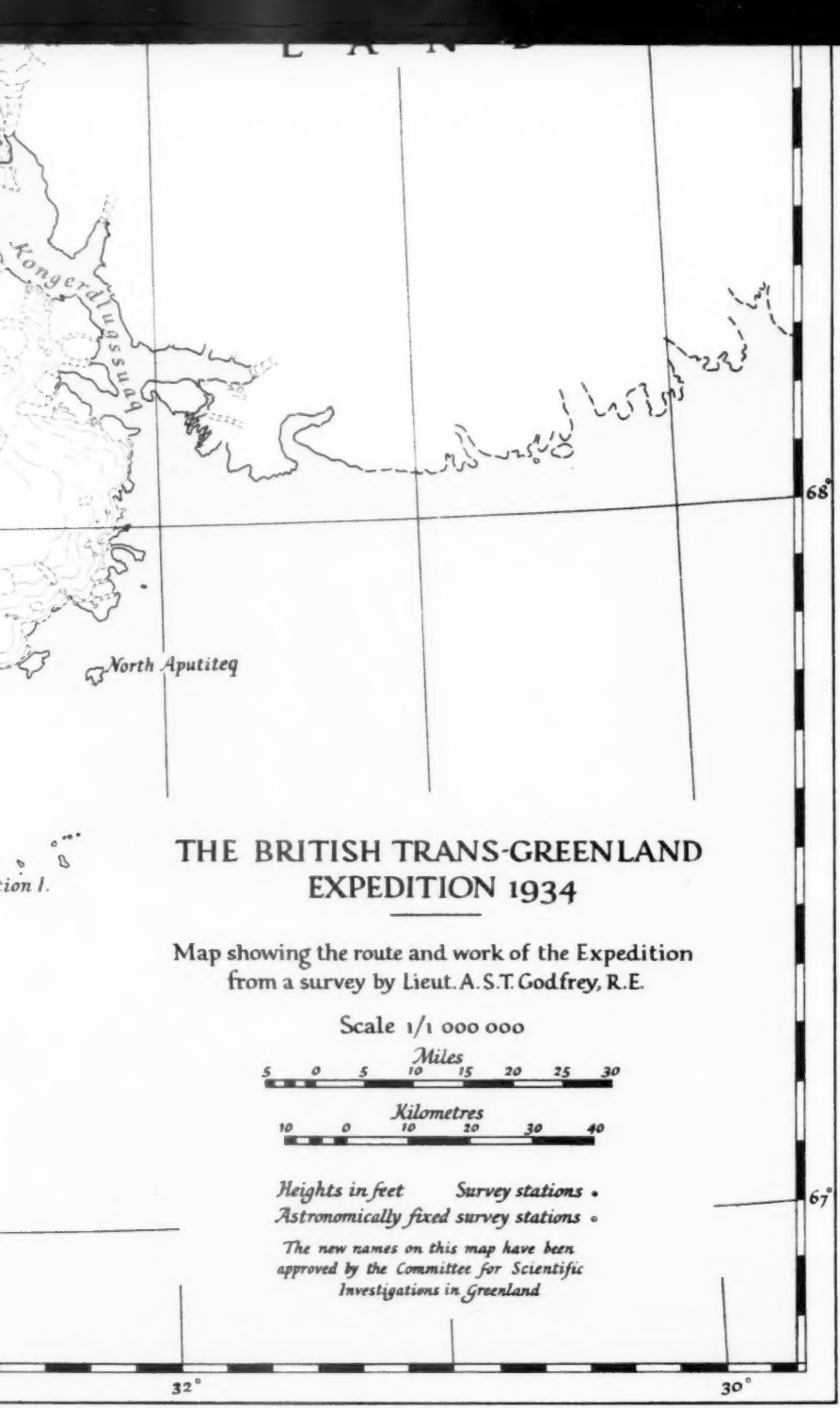

THE BRITISH TRANS-GREENLAND EXPEDITION 1934

Map showing the route and work of the Expedition
from a survey by Lieut. A.S.T. Godfrey, R.E.

Scale 1/1 000 000

Miles
5 0 5 10 15 20 25 30

Kilometres
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Heights in feet *Survey stations* •
Astronomically fixed survey stations ◦

The new names on this map have been approved by the Committee for Scientific Investigations in Greenland

EAST GREENLAND
British Trans-Greenland Expedition